THE INTERVENTION EFFECTIVENESS OF A VARIANT OF DISTRIBUTIVE LEADERSHIP IN UNDERGROUND SECTION MINING

by

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STATEMENT OF THESIS APPROVAL

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ABSTRACT

Decentralized leadership has become a key facet in the development of a learning culture within organizations and industries that sustain successful operations amid high levels of risk. Lessons from the U.S. military in Iraq and Afghanistan indicate the demand for fluidity to adapt and adjust to complex environments. This in turn has required a deviation from the military's rigid centralized leadership structure, established over the last couple of centuries, allowing personnel on the ground and within enemy lines the authority to make mission-imperative decisions.

The mining industry as a whole is faced with similar demands, requiring companies to become fluid and establish a learning culture, for success in an era defined by increased production, increased environmental responsibility, and lower levels of acceptable risk. This thesis investigates the intervention effectiveness of a variant of distributive leadership in an underground mining section. Using leadership traits established in a competency model for small unit leaders in the military, section miners underwent leadership training and coaching and were then charged with taking over decision making processes traditionally performed by the section foreman and fire boss.

A conclusion of the intervention was difficult to render based on the hypothesis, but valuable insights were attained on the application of leadership in underground section mining, and for research design improvements in a replication of this study or similar studies.

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1. INTRODUCTION

The modern challenges of the mining industry include an array of increasingly complex demands. At the forefront of these, miners are expected to maintain or increase production output while complying with federal safety regulations, often with an organizational expectation of achieving zero harm. The mining industry has made progress in defining acceptable risk and reducing fatalities over the last few decades, but still faces social and technological challenges, and miners continue to die in coal mines. Engineering efforts continue to identify and improve the vast number of systems involved in mining; however, a key element of these systems lacks attention. As the complexities of mining continue to increase, additional efforts are necessary to improve the human element of mining systems.

In addition to government safety regulations, the U.S. mining industry has adopted behavior-based safety programs aimed at modifying safety culture through individual behaviors (Fredrick and Lessin 2010). Some companies in the mining industry are taking whole systems design approaches, incorporating safety into an operation's leadership, culture, and systems (Hethmon and Nelson 2013). There is a consensus acknowledging the demand for leadership development in mining, and attempts have been made to identify useful methods of leadership specific to mining, based on traditional leadership models established in academic literature (Mclaggan, Bezuidenhout and Botha 2013). Many companies attempt to improve the leadership of their manager

but seldom in an empirically sound way. Currently there is no known literature addressing the intervention effectiveness of different leadership strategies in underground section and mining operations.

During the last decade of global antiterrorism operations, the U.S. Military has invested heavily in leadership research and implemented unique operational tactics, custom to the demands of modern warfare. In the business world, professionals have collaborated with academia to explore new patterns, methods, and components of effective leadership, such as leading with emotional intelligence (Goleman 1998), shared or distributed leadership (Gronn 2002; Day, Gronn and Salas 2004; Peirce and Conger 2003), and effects of charismatic, transactional and transformational leadership (Daft 2015). However, the majority of these studies are specific to education, manufacturing, sales, or industrial environments that do not relate closely to mining.

In over two centuries of warfighting, the U.S. Marine Corps has developed a rigid leadership culture, where individual Marines are indoctrinated with basic leadership traits and principles that if practiced, enable situational awareness, communication, trust, and accountability in small teams. These leadership outcomes serve any organization well, but are essential in addressing the hazards associated with underground mining. As both the U.S. military and the mining industry have made significant technological advances to improve operations over the last century, only the military continually invests in leadership.

Numerous parallels between U.S. military and mining operational risk and cultures, and provide a platform in establishing leadership competencies suitable for the mining industry. In the U.S. Marine Corps, it is not uncommon to see a 19-year old Lance

Corporal with six months of training, be responsible for a multimillion dollar weapons system. In the same sense, the mining industry employs hourly personnel, typically with secondary education to run and maintain operational-dependent equipment such as a haul truck or longwall shearer, both worth millions of dollars. Individual responsibilities in both cases will only increase as technology advances.

Success in modern warfare requires a higher level of individual technical proficiency and situational awareness. Individuals must think quickly on their feet, making life and death decisions in seconds. Typical training on conventional warfare tactics has been completely revamped to provide individuals with a higher level of basic skill sets. Core leadership principles are embedded with this technical training and standardized during the team building process. Some of these core leadership principles may transfer effectively into mining applications.

1.1 Statement of Problems

Aside from mining, organizations who operate successfully amid extremely hazardous conditions and catastrophic consequences of failure (i.e., in refining processes) are known as High Reliability Organizations (HROs). HROs have established industry wide standards for error-free health, safety, and environmental (HSE) performance (Lekka and Hill, 2011). These organizations exceed the demands of compliance to consider the complexity of modern operations and their stakeholders, to generate evolving systems, a just and learning culture, and shared and mindful leadership.

Currently, there is no consensus for a leadership standard in the mining industry. Also, there is no consensus leadership strategy for influencing positive change in mining culture, increased efficiency in mining systems, adaptation to complexity, and prevention

of catastrophes. The interdependence of leadership, culture, and systems is viewed by some in industry as the optimal fame work operational excellence, especially in high-risk industries (Hethmon and Nelson 2013). This research is intended to contribute to the formalization of a leadership standard in the mining industry.

As mentioned, a holistic approach to improving systems has gained momentum in other industries (Charnley et al. 2011) and in general business modeling. However, in mining, these holistic approaches are limited to mitigating financial risk and have not been normalized in addressing technical failures, political, economic, and social issues or health and safety issues. The mining industry as a whole continues with reductionist methods of problem solving and systematic analysis, because for generations, engineers, scientists, and managers prepared themselves to solve complex problems by becoming increasingly specialized and reducing problems to their constituent parts and focusing their attention on each part (Charnley et al. 2011). Engineers and designers are no longer trained across fields, and thus, no longer keep up with the latest breakthroughs in every field (Stasinopoulos et al. 2009).

1.2 Thesis Objective

The purpose of this research is to evaluate leadership applications in the mining industry. Beyond that, it is an effort to build on current leadership practice in mining for the holistic approach to systems design, which considers leadership, systems, and culture (Hethmon and Nelson 2013); see Figure 1.1.

The exponential growth of complexity, operational demands, economic fluctuation, and enterprise risk, require engineers to come better equipped to hurdle the mining industry's challenges. This research and similar efforts are valuable to the mining

industry and safety critical organizations as the groundwork for a leadership standard is established and integrated into academic curriculum, engineering practice, and mining operations to produce a safer more productive mining industry.

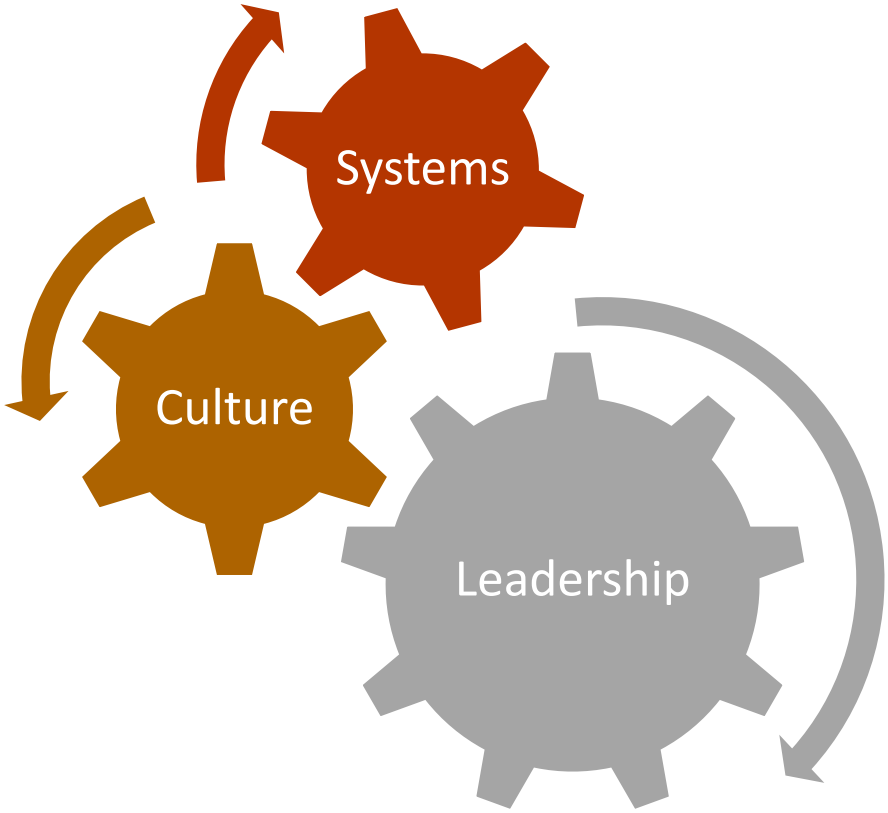

Figure 1.1 Leadership, Culture and Systems Framework

2. LEADERSHIP THEORY

2.1 Paradigms and Levels of Leadership Conceptualization

Leadership theory has evolved over the last century. Where leadership traits were once considered instilled at birth and manifested through heroic figures, it is now commonly accepted that principles (skills) of leadership can be learned (Daft 2015, Goleman 1998, Northouse 2013). Research in leadership theory has expanded to such a degree that today it is conceptualized in many different ways. For example, one author may describe several general approaches to leadership that contain subcategories of leadership styles, further divided into leadership models, consisting of specific leadership competencies. Others may label such a leadership model as its own general approach (Daft 2015, Northouse 2013). In application there is some ambiguity as multiple approaches to leadership are effective and a specific model of leadership can represent a general approach. In well-executed leadership, these theoretical concepts are refined by the user. See Figure 2.1 for an image of leadership conceptualization.

2.2 Traditional Leadership Approaches

A majority of leadership literature has been focused on traditional leader-follower transactions with a hierarchical structure and with a central leader at each level (Gronn 2002). Two main ideas under this paradigm include the resonant and dissonant approaches. The main difference between these two approaches is in the way that a leader

interacts with followers. The resonant approach includes visionary, coaching, affiliative, and democratic styles of leadership, which in all cases require the leader's investment in followers. The dissonant approach to leadership includes pacesetting and commanding styles. These styles may include a harsh interface between the leader and follower, but can be useful or necessary under certain circumstances, particularly where a specific set of standards must be upheld and where leader-follower transactions involve strict obedience (Daft 2015).

Other traditional concepts in leadership research include the trait and skills approaches. The trait approach has been the most refined and studied approach over the last century. However, the trait approach stems from the "great man" theory of leadership, where different qualities were observed in successful military, religious, and political leaders, then outlined as "traits" that may qualify someone to be a natural born leader (Northouse 2013). The skills approach is similar in that it outlines necessary skills to be a successful leader, but assumes that most skills can be learned. Both of these approaches are still utilized, specifically in the military. Though dated, these approaches provide a strong introduction to basic leadership principles, which serves as a platform as individuals develop leadership styles.

2.3 Contemporary Leadership Approaches

Contemporary leadership approaches have stemmed from the demands of complexity in organizations world-wide and are being applied at multiple organizational levels. Again, different approaches to leadership are defined based on leader-follower transactions and still fall under the paradigm of a hierarchical (focused) leadership structure with a central leader. In general, these approaches include moral and servant

leadership, leading through power, and leading through influence. The transactional, transformational, charismatic, and coalitional models of leadership, represent the various approaches and models of influential leadership (Daft 2015). Certain leadership approaches and models may be more effective than others based on operational demands, culture, and employee skill levels. A transformational leader is most effective at aligning his or her subordinates (or peers) towards a certain vision, while a transactional leader is more focused on getting subordinates to accomplish a task, through a process of transactional compromise, i.e., simply paying an employee the agreed wage for completion of a certain task.

2.4 Leading vs. Managing in Mining

There is no consensus leadership model in the mining industry, as different applications of mining may require more than one particular approach to leadership in order to effectively reach production and safety goals. When mining operators do practice a regular form of leadership, it is typically one in the traditional hierarchical leadership structure and transactional. In cases where there is a void in leadership, an operation relies on routine planning, organizing, staffing, and controlling, all basic functions of management (Northouse 2013). Establishing standard operating procedures or regulations can improve work environments, but do not entirely account for the complexities of mining operations or the human element of mining systems. It is important to distinguish between the functions of management and leadership, with management's role being to provide order and consistency to an organization while leadership provides change and movement. The concept of leadership has been explored dating back to Aristotle, whereas management was created more recently in the industrial revolution, to prevent chaos in

the workplace (Northouse 2013). A good leader must grasp and execute both concepts.

2.5 Distributive, Shared, and Participative Leadership

In underground section coal mining, multiple hazards require individual miners to be aware of their surroundings, to be technically proficient, and to communicate efficiently with their fellow miners. In an application where such a mix of independence is required, leadership could be viewed as a relational phenomenon, where formal leaders and followers share in the process of enacting leadership (Drath 2001). This pattern of leadership, being spread or shared across a group rather than coming from a central figure, was first noticed by the Australian leadership theorist C.A. Gibb in the 1950s, and is most often referred to as distributive leadership (Gronn 2002). This structure of leadership relies on strong individual capabilities, yet promotes cohesion through interdependence and accountability as individual group members conform to standards.

Pearce and Conger in the book *Shared Leadership: Reframing the Hows and Whys of Leadership,* define shared (distributive) leadership as "a dynamic interactive influence process among individuals in groups, for which the objective is to lead one another to the achievement of group or organizational goals or both" (Pearce and Conger 2003). Because distributive (shared) leadership represents an entirely different structure of leadership processes, as compared to the traditional hierarchical leadership structure, individuals may adopt leadership competencies from transactional, transformational, coalitional, and several other leadership models (Hoch, Pearce and Welzel 2010); see Figure 2.1.

Carson, Tesluk and Marrone (2007), define distributive or shared leadership as "an emergent property that results from the distribution of leadership across multiple

team members; it represents a condition of mutual influence embedded in the interactions among team members that can significantly improve team organization and performance." Their study draws attention to this important "property" of distributive leadership, where leadership acts as a team output and feeds back into the cycle of a leadership culture. This theme reoccurs in a discussion of the processes of teaming and the leadership capacity of teams (Day et al. 2004), where instead of acting only as an input, in the linear Input-Process-Output (I-P-O) model of teaming leadership is the input and output of a cyclic-process described with the acronym; inputs, mediational influences, outcomes, inputs (IMOI). In this situation, leadership is not only an input, but a by-product of the interaction among teammates that feeds back into the cyclic-process, harnessing a leadership culture within the team and increasing the overall leadership climate.

2.6 Distributive Leadership vs. Self-Managing Teams

The outcomes of distributive leadership and self-managing teams draw multiple parallels. Literature regarding self-managing (self-directed) teams typically includes some discussion of distributive (shared or participative) leadership (Day et al. 2004; Hoch et al. 2010; Huang et al. 2009; Manz and Sims 1987; Mehra et al. 2006). Shared leadership has also become a discussion in team leadership, where improvements in communication and trust are desired outcomes. Though the subjects are closely intertwined, distributive leadership involves a spread of influence and self-managing teams involve distribution of authority. It is important to note that, distributive leadership is applicable to multiple units of analysis, while team leadership is specific to a single unit (teams).

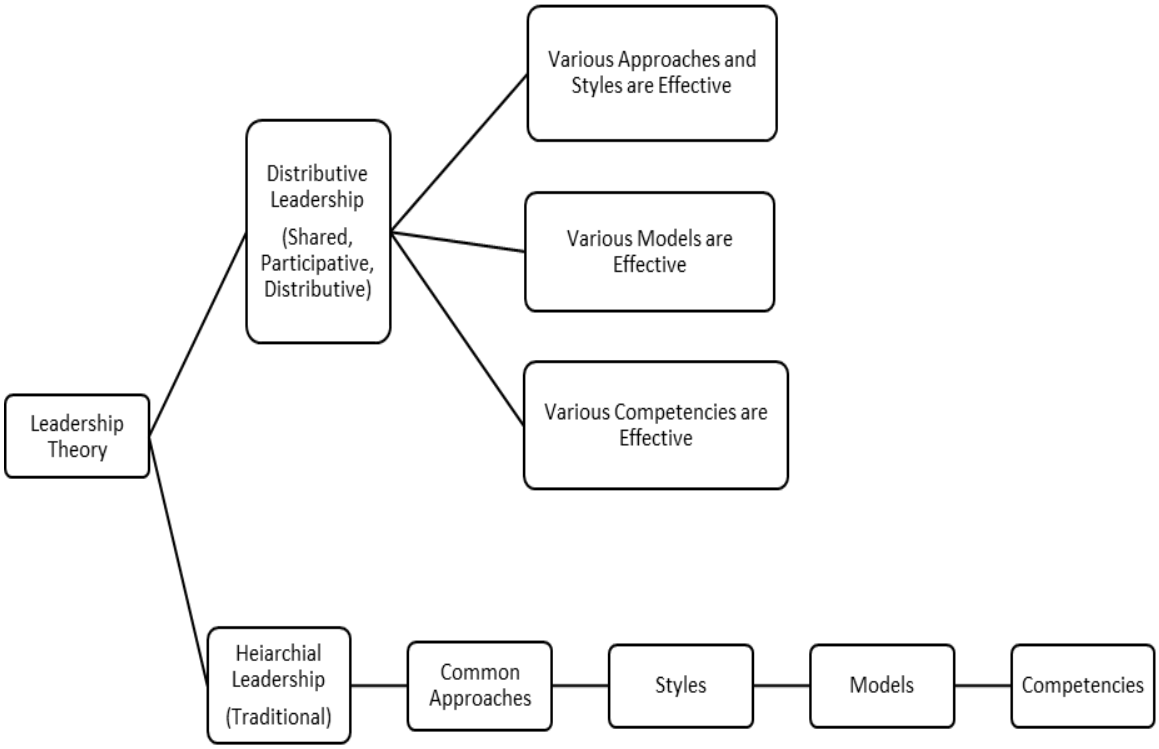

Figure 2.1 Leadership Theory Conceptualization Model

3. MILITARY LEADERSHIP PRINCIPLES IN MINING

3.1 Military Small Teams vs. Underground Coal Mining Section

Similar to the front line units in a combat environment, miners who work on the face of a coal mining section are subject to the majority of hazards associated with underground coal mining. Small teams in both environments are the "back bone" of operations and rely on efficient teaming processes. Success in both scenarios depend on how well the team process is executed, which is determined by the leadership interactions among team members.

There are also parallels in the structure of military infantry units and underground mining sections. An underground mining section typically is managed by a foreman who is placed according to experience or some level of education, and oversees 8 to 12 people. The foreman is accompanied by a fire boss, who inspects the mine face and assists the foreman with coordinating and directing task between miners. The squad level in a Marine infantry unit is supervised by a squad leader, who oversees 10-16 Marines. The squad further delegates authority to multiple team leaders, who oversee 3 to 5 Marines. Team leaders are the lowest level of small unit leadership in the Marine Corps. Team leaders must be efficient at both relaying and executing orders from the squad leader, while also making life and death decisions. Even at the team leader level, Marines are encouraged and empowered to make decisions, but are also held accountable.

Operationally, both a section foreman and Marine squad leader perform work

responsibilities independent of the larger organization. This requires a certain level of experience, and in the case of a Marine squad leader in combat, certain leadership capabilities to motivate subordinates and enable communication. The same leadership abilities, are considered in this intervention but will be introduced to all miners in the section in addition to the foreman and fire boss.

3.2 Military Leadership and Industry

The U.S. military has been training leaders for about 213 years, dating back to the establishment of West Point. Many mistakenly believe that West Point (or sister institutions such as the U.S. Naval Academy or U.S. Airforce Academy) prepare leaders only for military applications. While many graduates make the military a career, others serve their initial five-year active duty obligation, then enter industry or government and apply the same skill set. Wendy's, Johnson & Johnson, Proctor and Gamble, Goodrich and Footlocker have all been led by CEOs from one of these military institutions (Winn and Banks 2014).

3.3 Leadership Competencies Suitable for Underground Section Mining

The skills and trait approaches are useful in introducing leadership principles to individuals with little to no prior experience or training in leadership. Most of the other approaches to leadership define specific methods to leader- follower interactions (e.g., LMX) where the skills and trait approaches outline individual competencies. The Marine Corps operational standard on leadership, *Principles of Marine Corps Leadership* (RP 0103) includes 14 leadership traits that underlie 11 leadership principles. These traits and principles are included in the standard competency model for each Marine, instilled

during boot camp, and then continuously refined. The following list includes four traits and three principles adopted from this publication that are suitable for implementation in an underground coal mining section, and feasible for implementing a leadership safety program.

3.3.1 Traits

- Judgment – the ability to weigh facts and possible courses of action in order to make sound decisions
- Dependability – the certainty of proper performance of duty
- Decisiveness – the ability to make decisions promptly and to announce them in a clear manner
- Knowledge – the range of one's information, including professional knowledge and understanding of coworkers

3.3.2 Principles

- Know yourself and seek self-improvement
- Know your people and look out for their welfare
- Seek responsibilities and take responsibilities (accountability)

4. HYPOTHESIS

4.1 Role Delineation in Distributive Leadership

Distributive patterns of leadership (i.e., shared, distributive, and participative) can be categorized based on the proportional strength of social influence between mangers and subordinates, or among peers. A complete distribution of leadership is considered "weak" in influence proportion, whereas shared or participative leadership is "strong" (Gronn 2002, Shamir 1999). A variant of distributive leadership is anticipated to be realistic for implementation in an underground coal mining section; where a social form of "*division of labor"* is feasible in comparison to a complete social and technical division of labor, as no new equipment or technologies are expected to be introduced (Gronn 2002).

Traditionally the responsibilities of a section fireboss and foreman parallel those of a small unit team leader and a direct "manager." Typically, the section fire boss ensures work flow by directing the task of individual miners and keeping the mine face supplied, performs preshift inspections, and reports to the section foreman. Depending on how involved a section foreman chooses to be, some responsibilities are interchangeable with the fire boss, e.g., the foreman may direct activities on the face, while the fire boss performs inspections. A rigid definition of responsibilities depends on the mine (organized labor status), the relationship between the fire boss and foreman, and experience of miners in a section. In general, the foreman is accountable and responsible

for section operations and makes decisions as to the order of daily tasks.

Given that a shift to distributive leadership involves proportions of influence, the work tasks and delegated authority associated with the section fire boss and foreman positions remain in place. However, as the leadership traits and principles discussed previously are standardized among all crewmembers, some level of authority should be shared so that individuals participate in the decision-making process. In a study of external leadership in self-managing teams, positions traditionally held by the foreman were filled by a "coordinator" (Manz and Sims 1987). Because the concept of "self-managing teams" involves a complete shift in authority (opposed to influence) to all team members, it is not completely applicable in practicing distributive leadership; however, the section foreman does need to adopt some functionalities of a "coordinator" while crew members participate in the decision-making process. This study is intended to validate that an increase in leadership climate through distributive leadership will affect the psychological empowerment of individual miners.

4.2 Psychological Empowerment

Psychological empowerment has been conceptualized as a multidimensional construct consisting of (a) impact, i.e., degree to which an employee feels his or her work affects an organization, (b) competence, i.e., perceived ability to accomplish work-related task, (c) meaningfulness, i.e., intrinsic caring about work task, and (d) choice, i.e., perceived self-determination or autonomy (Kirkman and Rosen 1997, 1999; Spreitzer 1995; Thomas and Velthouse 1990). Different perspectives on empowerment were sought by (Thomas and Velthouse 1990) to distinguish between situational attributes (i.e., management practices) and job incumbent cognitions about those attributes (e.g.,

psychological empowerment). This work provides a more precise definition of empowerment and differentiate between psychological empowerment and structural empowerment (i.e., the delegation of authority and responsibility to employees). This concept is important because "psychological empowerment has been shown to transform individual behaviors above and beyond the capabilities of structural empowerment alone" (Wallace et al. 2011).

4.2.1 Hypothesis$_0$

H_o: An increase in leadership climate through training and implementation of a variant of distributive leadership correlates to a positive change in psychological empowerment among individual miners in an underground coal mining section.

4.3 Situational Awareness

The essential ability to "see – anticipate – avoid" peril was identified by teams of researchers addressing critical contexts like air combat, space shuttle, and nuclear plant operations among others, as the ability of the individual to respond safely and competently with preventative actions in a timely manner. The phrase "situational awareness" (SA) was coined in the late 1960s and is generally defined as the person's ability to perceive, understand and project outcomes in what goes on around them (Rosenweg, 2001). (Endsley 1995) further defined situational awareness as:

a. **Perception** - Seeing. The first step in achieving SA involves accurately seeing what is going on around you, what the people, equipment, and systems are doing as well as any incoming information.
b. **Comprehension** - Understanding. Perception is followed by understanding

the situation elements with respect to the operating goals, to form a total picture of the environment.

c. **Projection** - Thinking ahead. The capacity to project the future actions or outcomes of the elements in the environment, at least in the short term.

4.3.1 Hypothesis$_1$

H_1: An increase in psychological empowerment correlates positively to a change in productivity, perception towards safety and situational awareness among individual miners in an underground coal mining section.

5. RESEARCH DESIGN

This study assesses the intervention effectiveness of a variant of distributive leadership with confidential perception surveys and safety and production outcome measures, using a quasi-experimental design. The intervention involves two phases with a cohort of two continuous miner production crews (one intervention crew and one control crew) over a 60-day period. An underground, nonunion coal mine in central Utah agreed to serve as the study partner, allowing access to two production crews and any related production and safety data generated relative to the crews through the duration of the study.

5.1 Methods

Because the two participating crews were selected by mine management, the study design is quasi-experimental. Threats to internal validity relative to this quasi-experiment include the history threat, i.e., changes in work processes, pace or structure, testing threat, i.e., changes that occur because the test was performed, placebo threat, i.e., a psychological mechanism when participants indicate change though no change has been implemented, Hawthorne threat, i.e., changes behavior due-to the presence of researchers, and the dropout threat, i.e., where participants choose not to follow through with the study. Internal validity specific to control groups includes the regression-to-the-mean-interaction threat, i.e., where the participants are selected based on need, diffusion threat, i.e., where the intervention leaks into control groups, and the rivalry threat, i.e., where

control groups make changes in a competitive effort against the intervention group (Robson et al. 2001). To ensure viability of the data and to maintain a quasi-experimental standard, data were collected from a control crew who received no training or intervention, this effort was included specifically to control the history effect.

For logistical reasons, a weekend crew (three, 13.5 h shifts) was selected as the intervention crew, and the control group, a week-day crew (five, 8 h swing/grave shifts). In order to reasonably compare production data and other data affected by specific mine-section conditions, both crews were mining the Three Right-West Lease Four development section. This assisted in minimizing the Hawthorne effect and control the validity threats specific to control groups (Robson et al. 2001). Additional outcome measures were included in the surveys to determine if the intervention was or was not effective.

A legitimate time series design was not feasible because the study was limited to 60 days and the use of multiple measurements were limited because the surveys required substantially more time to complete than was anticipated. A mid-intervention measurement was taken but did not include the situational safety awareness test. The test took some miners over an hour too complete and heavily impacted the logistics of getting all miners to the section in the same trip, as well as rotating on and off tasks if miners took the test underground. A journal of the intervention was utilized to supplement the data collected, while also identifying any dropout or history effects. The additional outcome measures assisted in controlling the history, Hawthorne and placebo effects; see Figure 5.1.

The cohort consisted of two continuous miner production crews, with one

designated to undergo the leadership intervention, in the form of leadership training, observations and coaching. Both crews participated in the surveys. Each crew consisted of approximately 8-11 miners.

The training was implemented in two phases. In phase one, the section fire boss and foreman were instructed on the functions of distributive leadership, and received training and instruction on the basic leadership competencies mentioned in the previous section in the leadership background, and military leadership competencies suitable for mining. A pocket guide called the "Miners Guide to Shared Leadership" was developed for the intervention and utilized both as a reference and training tool, see Appendix A for the "Miners Guide to Shared Leadership." The foreman and fire boss were the first to receive training and complete a personal action plan, which included an inventory of the skills and competencies in which they were efficient, and those that needed improvement. After determining the skills each needed to improve, learning tools were provided in the form of reading materials, as well as coaching.

5.1.1 Phase One of the Intervention

During phase one of the intervention, an attitude consensus was observed, which is explained later in the analysis. The foreman then participated in the decision of how to delegate leadership to his crew. This was considered an important aspect of the intervention, as it allowed for the crew to take ownership of the change. Before leadership was handed over, each miner in the crew spent 2 to 5 hours receiving instruction on leadership competencies using the "Miners Guide to Shared Leadership," discussing the overall morale and leadership climate at the mine, and discussing their own perceived leadership abilities.

After each crew member received leadership training and instruction, the foreman was encouraged to lead a discussion with the crew to determine a set of core values, a vision, and goals, specific to their mining section. This was used to generate a standard to which individuals could hold each other accountable.

5.1.2 Phase Two of the Intervention

Phase two of the intervention involved reorganization of the crew's leadership. During this phase, the foreman and fire boss distributed the traditional functions of leadership allowing individual crew members to participate in the leadership process, i.e., directing tasks. This phase of the intervention included follow-up training, observations, and coaching as needed, and heavily relied on the ability of the foreman and fire boss to encourage individual leadership. Simultaneously with this transition, crew members continued to identify their personal leadership skills and seek improvement. Training was provided one to two times a weekend during this phase in the form of instruction and coaching, to ensure individual crew members had the assets necessary to improve their individual leadership skills. See Figure 5.2 for a process flow diagram of the intervention.

5.2 Measures

Baseline and postintervention perception surveys were adopted from validated questionnaires and supplemented with semi structured interviews, observations, and safety and production data provided by the mine. Two surveys were distributed before, during, and after the intervention. A general miner perception survey integrated questions measuring leadership climate and psychological empowerment was distributed first, followed by a survey measuring situational safety awareness.

Psychological Empowerment was measured using a 12-item, 5-point Likert scale instrument (5=strongly agree, 4= agree, 3= neutral, 2= disagree, 1= strongly disagree) adopted from Gretchen Spreitzer's research on "Empowerment in the Workplace" (Spreitzer 1995*).* Questions from this work were integrated into the general miner survey.

Situational Awareness was measured using the Situational Safety Awareness Inventory, Questionnaire V5.0p, provided by *Psyfactors, Pty Ltd*. The survey is specifically directed at measuring situational awareness in mobile equipment operators in the mining industry. This was a pen and paper version of the instrument, thus allowing miners to complete the survey in between tasks underground. The survey took miners in both crews an extensive amount of time, i.e., 45 – 85 min to complete, so it was only used as a base line and postintervention measurement.

The survey consisted of 115 questions measuring (1) perception, (2) comprehension, and (3) projection. In a sample size of N=15,444 the questionnaire was validated with a Cronbach's Alpha of 0.89, with $p<0.05$. The measurement criteria consisted of positive coping skills, mental alertness, manages fatigue, general hazard awareness, perception and comprehension, defensive safety habits, safety self-awareness, responsible for safety, risk avoidance, safety conscientiousness, and team and safety orientation. Each respondent remained anonymous for the protection of his or her identity. In a future study, it is recommended that each of the respondents receive an alias for the questionnaire to assist in providing better feedback to individuals who participate in the study, improve the efficiency of data collection, and quality of the overall analysis. A group average was calculated and compared against the average taken from respondents reporting <10% safety incidents over a 14-month period.

Leadership climate was measured using the following subvariables; trust, communication, innovation, task proficiency, and dependability. These variables were combined into 17 previously validated questions. These questions were included in the general miner survey, using a 5 point Likert scale (5=strongly agree, 4= agree, 3= neutral, 2= disagree, 1= strongly disagree). Reference Table 5.1 for a list of the different data sources.

5.3 Analysis of Survey Responses

Quantitative and qualitative forms of analysis are useful to analyze the study data, considering the range of data and the sample size restriction. Supplemental data were collected through interviews and observations in the form of an intervention journal. This enabled a more thorough interpretation of the numeric data, e.g., it is possible that production levels decreased because of the holiday schedule over the months of November and December, 2015. In this regard, a strict quantitative analysis alone is less reliable for interpreting the collected data or validating the proposed hypothesis.

In the case that this study is replicated with 145 or more participants, the design is sufficient for using a form of multivariable analysis to analyze correlations among the variables in hypothesis one, and multivariate analysis, i.e., linear regression or Multivariate Analysis of Variance (MANOVA) for hypothesis two. A larger number of participants will also provide statistical significance for using factor analysis to group the variables associated with the leadership climate, situational awareness, and safety constructs and use of the *p*-value, confidence intervals or two-sample *t*-Test, to validate the overall intervention effectiveness (Robson et al.).

Table 5.1 Data Sources

Data Source	**Outcome Measurement**
Perception Surveys	Leadership Climate, Psychological Empowerment, Situational Awareness
Semi-structured Interviews	Leadership Climate, Psychological Empowerment, Safety Climate
Observations	Leadership Climate, Safety Culture, Psychological Empowerment
Safety Data	Safety Perception Survey and Reportable Safety Data
Production Data	Productivity, Group Efficiency

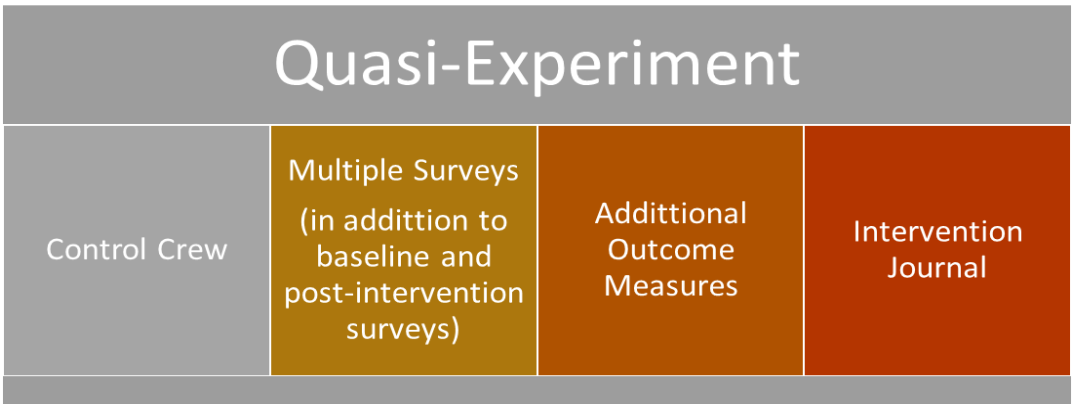

Figure 5.1 Quasi-Experimental Controls

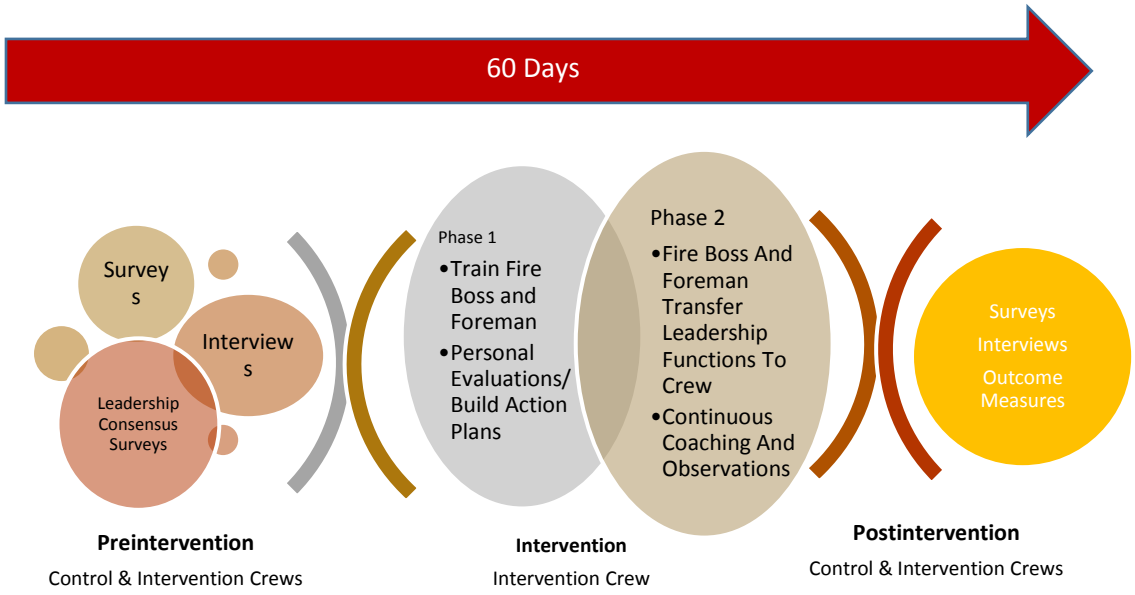

Figure 5.2 Intervention Stages and Time Line

6. ANALYSIS

In this study the number of participants (i.e., *N*=9), was useful for gaining insight on the topic but insufficient to achieve statistical power to validate the data collected through the perception survey responses. A larger more randomly selected cohort, (i.e., the whole mine or multiple crews) would provide the number of participants needed to show significance and justification for the use of a form of multivariate analysis. Multivariate analysis is useful for research with this design, where implementation of a general concept such as leadership climate, requires manipulation of multiple control variables (i.e., independent variables) which are measured against a small or lesser number of intended outcomes (i.e., dependent variables).

To supplement the surveys, data were collected in the form of discussions, interviews, and an intervention journal. This analysis contains both a quantitative and qualitative summary of the data collected. Each phase of the intervention is discussed along with any corresponding subjects and the data from the perception surveys and the situational awareness survey.

6.1 Intervention Notes, Discussions, and Interviews

The following *includes* notes from the discussions, interviews, and intervention journal starting with a preintervention phase, phase one and, phase two.

6.1.1 Preintervention and Overall Culture of the Mine

There was a certain bias introduced prior to beginning the intervention, as the mine operator's shift supervisors decided upon the cohort. Specifically, the intervention crew was chosen based on need for development and, a hope that the training would improve their overall attitude. For the changes caused by the intervention to be observed in a comparative analysis and to address the regression to the mean threat to validity, the study design included a nonintervention crew, who did not undergo leadership training or reorganization. The nonintervention crew did participate in the surveys.

The intervention crew's fire boss was assigned specifically to the crew to assist the foreman with work flow, because of the crew's unsatisfactory performance and poor attitude, but not lack of experience. He had approximately 15 years of experience with 5 to 7 years as a fire boss. He typically managed work flow in the section by micromanaging and pace setting, which for the circumstances was effective to keep the section moving forward. This was problematic for the implementation of shared leadership.

The section foreman was previously assigned to another crew who had worked and performed well together. His previous crew functioned autonomously, similar to other sections at the mine (to include the intervention crew), but more within his performance standards and values. This allowed the foreman to focus on tasks specifically related to his position and communicate with the shift supervisor, so that little to no leadership skills were required, only simple management of the section.

The mining section where the intervention and nonintervention crews operated was 4,500 feet behind schedule and next in sequence to be mined by the longwall. The

conditions in the section were typical for the mine with an 8 to 9-ft mining height, regular ground water, shale top, and approximately 900 ft of overburden* There were occasional sets of faults which required additional roof support (trusses) and time for installation, but, in general, sequencing was normal.

Most equipment was worn down but functional with regular maintenance. It was noticed during the first section visit of the intervention that a screw driver was jammed into the reset button on the feeder breaker. This was to override a tripper that caused the feeder to continuously power down and required the shuttle car drivers to dismount and reset the feeder breaker before offloading coal.

Weekend shifts at the mine consisted of production crews for each section and the longwall, and a single maintenance crew on grave-yard shift. During the week, production crews mined through the swing and grave shifts, while a down shift advanced the section during the day. The intervention was granted initiation three weeks after the completion of a longwall move, and just before the end of the year when employees are encouraged to use up annual vacation. Upon completion of the intervention, the mine schedule was set to be reorganized to an industrial schedule, with redistribution of some crew members and shifts. Typically, MSHA** did not show up during the weekend shifts, and if they did it was during the day, Friday, on the first shift.

The mine operator compensates hourly employees based on a three-level pay scale (A, B, and C) with C-pay (i.e., approximately $23.75 per hour), for entry level

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*Overburden is the depth of material from the top of the seam being mined to the surface above.

**MSHA is an abbreviation for Mine Safety and Health Administration, the regulatory agency for mining in the United States.

miners, usually raised to B-pay within the first 18 months of employment. B-pay is the standard pay (i.e., approximately $26.75 per hour) for underground miners until they are promoted to a certain job (i.e., roof bolter, miner operator, etc.) entitled to A-pay (i.e., approximately $29.75 per hour). There are also shift differentials for working production on swing shifts, graveyards, and weekends. Foreman, managers, safety personnel, and engineers are paid on a salary basis.

The mine operator currently affects a large number of stakeholders locally, nationally, and internationally. The mine and a few other sister mines are corporate run from another state and regularly export coal overseas. Mine management (both upper and lower) are primarily tenure employees. Most of the mine shift and section front line supervisors are tenured as well. In many cases, multiple family members are employed at the mine, which has some effect on the hiring, firing, and promotional processes. During preintervention interviews, miners expressed frustration with management for hiring nonlocal employees who were absorbed after the closure of a sister mine.

The mine has had a strong reputation for safety over the last decade, using a seasoned behavior-based safety program. In the prior year, they accomplished 1,000,000 man hours of no-reportable injuries. Employees were awarded with a monthly safety and production bonus which accrued during long periods of no-reportable injuries, and at times reached 15%-30% of the miner's monthly income. After a reportable injury occurred, the bonus dropped to zero, then accrued again as no injuries were reported.

Within 3 weeks of the 1,000,000-man hour record (the prior year), 3 separate lost time injuries were reported, resulting in 2 miners experiencing severed fingers and one miner obtaining a bruised rib and a hip, from a blast during initial caving on the longwall.

At the start of the intervention, a year and a half after the reportable incidents, the safety and production bonus had only accrued to approximately 2%–5% of monthly income for miners. Miners expressed frustration with the decrease in their monthly bonus, as they had grown accustomed to it during the previous years. Frustration was fueled by a decrease in monthly bonuses and an increased push for production during the previous year. This had a significant negative impact on the culture of the section. More interviews and data would be useful to determine a mine-wide consensus of this issue.

A consensus was revealed during the interviews that safety management and operations management were not interdependent and lacked communication. While safe behavior was considered an obvious priority to all miners, front line supervisors were under strong pressure to boost production. For the miners, there appeared to be a certain amount of confusion to whether safe procedures or production goals were the priority. It is possible that this issue exceeds the level of upper management and correlates more directly with corporate leadership. More data could be useful to determine this. Overall, the mine's general management indicated a positive attitude towards safety.

6.1.2 Phase One of the Intervention

The intervention crew typically received training during one entire shift over the three weekend shifts (Friday–Sunday, 11:00 am – 12:45am). Due to limited resources, training was less rigorous and depended on availability of crew members. The foreman made instructional periods a priority, but one-on-one instructional sessions were time consuming (2 to 4 h) and limited the number of miners to be trained during the 13.5-h shift. This created conflicts in the overall project schedule when miners scheduled for training during the next weekend called in sick or took vacation. Adjustments were made

to handle these schedule conflicts, but some delays were inevitable. Generally, the training was well-received among members of the crew.

Phase one of the intervention was initiated with a series of interviews, discussions, and instructional sessions with the section foreman and fireboss. The section foreman was ambitious to improve his personal leadership skills and eager for other miners in the section to undergo training. The section foreman and fireboss were provided with an instructional manual which included leadership principles, the structure of shared leadership, a personal action plan outline, process improvement procedures, hazard analysis procedures and guidelines to their role in shared leadership. The manual, "Foreman's Guide to Shared Leadership," proved to be a useful tool throughout the intervention. It was created for the project and written in a language specific to an underground mining section.

The foreman who was naturally quiet, agreed that it was a priority to improve his communication skills. As a first step, different methods and forms of giving feedback were discussed (i.e., to groups, individuals, positive feedback, and negative feedback) and practiced. The foreman was also coached in leading a few discussions with the section, mainly to develop a short-term vision for the crew, a set of values, a set of goals, and a plan for their implementation. The initial training and instructional period was followed by weekly discussions and coaching through the duration of the intervention. The foreman saw value in having each miner undergo the same amount of instruction and training. He was supportive by allowing miners to pause work for instructional periods, coaching, and discussions.

The section fire boss underwent the same training and participated in follow up

sessions. He was receptive to the training, but frequently used the discussion time to elaborate on frustrations with management and the poor performance and attitudes of the miners in the section. The fire boss was an effective pace-setting leader. Pace setting leaders are beneficial for driving production, but may be prone to overlook process safety. The fire boss's pace setting leadership style proved to be a hurdle in implementing and nourishing the shared leadership structure, mainly because it was so effective under the current circumstances and cultural climate.

A few weeks into phase one of the intervention, each miner in the section completed initial training. An edited form of the instructional guide, "Miner's Guide to Shared Leadership," was given to each miner along with a wet-erase pen, to record notes and complete a personal action plan. During the completion of training, a majority of the miners were receptive to the information and maintained a positive attitude while completing the personal action plan.

Most miners used the discussion time to express concerns with current management, a negative cultural climate across the mine, frustration with the foreman for lack of feedback, the negative political climate towards coal, and the negative outlook on the future of the industry. However, after discussing these frustrations, most of the miners quickly moved on to the leadership material and foresaw the benefits of leadership applications in their daily routines and even personal lives.

The introduction of the shared leadership manual first provides a comparison between a fixed mindset to a growth mindset. Most of the miners agreed that previously they had approached each day with a fixed mindset, and agreed on the benefit of attempting to operate in a growth mindset. Transformation into a growth mindset can be

challenging as an individual, but less so as a team. This proved to be beneficial as all miners in the crew actively participated in the intervention. The review of possible mindsets was also a beneficial transition into the instructional material.

Each miner displayed an understanding of the leadership principles. While discussing these, a majority of the miners identified the items that needed improvement as a crew, but had difficulty in addressing items they could improve as individuals. This opened the discussion to clarify the difference between accountability and responsibility.

Accountability, a desired quality sought by many superiors, is difficult to obtain from employees on a voluntary basis. During this discussion, one of the miners was hesitant to take accountability for his responsibilities after being locked into B-pay for over 5 years, while the other crew members were earning A-pay, and he was capable of fulfilling the same responsibilities. It was a difficult subject to argue. The benefit of taking accountability was presented as self-satisfying. This was a highly optimistic solution, but reasonable suggestions were limited in this discussion. The miner had no prior feedback on his performance or goals set by supervisors to achieve the next level of pay.

During the instructional periods, miners discussed their overall role in the section as well as their individual responsibilities (i.e., roof bolter, miner operator, third man, shuttle car driver, and mechanic). For routine tasks, miners completed workflow diagrams to pinpoint normalization of deviance and look for more efficient, safer steps to complete each task. The discussion of these routine activities brought light to several process where improper procedures or short cuts have become acceptable, and where additional actions should be implemented for overall improvement. This was a useful

exercise for individual proficiency. Phase one was primarily instructional, except for coaching received by the foreman. In phase two, the section introduced leadership reorganization.

6.1.3 Phase Two of the Intervention

After each miner completed the initial training and the foreman and fire boss were instructed regarding their role in the shared leadership structure, phase two of the intervention was initiated. This occurred four weeks into the intervention. In phase two, the follow-up discussions with each miner, the foreman, and the fire boss continued. During the transition to phase two, the miner section was down due to a series of faults and the section belt being torn in half. The fire boss reported that the section was still behind approximately 4,500 ft.

As a daily routine and at the beginning of each shift, the section foreman would briefly review over the daily agenda with the crew and relay any special instructions from the shift supervisor. For example, this could be an order to advance the section belts and power, rather than mine coal, or to install a particular pump, or to build a seal. The miners would eat, gather equipment, and dress in rain gear during this time, over approximately 25-35 min, then walk to their respective equipment on the face. Because MSHA was not likely to show up during the weekend shifts, required preshift inspections on equipment were not completed regularly. The fire boss would accompany miners to the face, provide each miner with specific instructions for those tasks, and then proceed to do daily preshifts (i.e., inspections of the face and belt line). Sometimes the preshifts would take place after lunch, depending on specific task laid out in the daily agenda.

With the initiation of phase two, the foreman simply gave an overview of the

tasks that needed to be completed at the beginning of each shift as directed from the shift supervisor. The miners would then decide who should accomplish each task and when. This provided an opportunity for miners to step outside their routine tasks, cross train, and improve upon their own skills by training others.

A significant number of ideas were exchanged and discussed during phase one of the intervention, during the one-on-one interviews with the principal; however, miners were hesitant to mention the ideas during an initial group discussion in phase two. The restricted flow of communication appeared to correlate with a lack of trust between miners and the section foreman. In one conversation led by the section foreman after initiation of phase two, miners sat quietly at the kitchen table after being asked to discuss their ideas for improving the section. Once the conversation was initiated by the principle, miners started conversing openly as a group. This initial group discussion was used to surface common concerns brought up during the individual interviews in phase one, and functioned as an aid to the foreman for use in future group discussions. This was a difficult task to accomplish in the intervention but it was pivotal. It was routine for the section miners and even the fire boss and foreman to participate in in-depth discussions, but rarely was the subject matter related to personal improvement, leadership development, or performance as a section. An action plan was agreed upon after the discussion to address the common concerns, and implementation of the action plan was left to the crew members.

At the beginning of phase two, the miners were very receptive to the reorganization of leadership. The crew agreed that the roof bolters could be more productive if they were relieved more frequently. This was achieved by rotating miners

off of the roof bolter[***] to drive shuttle cars, cross train on the miners, and to complete other required tasks in the section, even serving as a third man on the bolter (i.e., bolter assistant). Also, there was a secondary roof bolting machine in the section that was put into action in the alternate entry, while the primary bolter kept on sequence. This also alleviated pressure from the section's designated roof bolters. The impact of reaching this consensus among the miners was significant considering the importance of roof control and the poor roof conditions in this section. The action itself was a product of communication among the miners (i.e., a leadership trait) rather than a direct result leadership reorganization. The decision to focus attention on assisting the roof bolters was a byproduct of leadership reorganization and, ultimately, this positively affected the section's roof control.

At this point in the intervention, the foreman and fire boss noticed improvement in the overall attitude of the miners. Some miners went above and beyond their normal responsibilities, taking initiative to complete routine tasks without direction, such as hanging emergency escape way line as the section advanced and completing other tasks during down time that would normally be completed during the down shift. Some miners also reported an increase in feedback from the fire boss and foreman. After the transition into phase two, interviews and discussions were continued, typically during one shift over the three weekend shifts. Coaching was also provided during this time with

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[***] Roof bolters are the miners responsible for inserting wire mesh and rebar bolts into the mine roof. This is done as control measure, which forms the individual layers of rock above into beams that are less likely to cave onto the miners while working. The wire mesh protects miners from loose fragments that might fall. Typically roof bolters follow in sequence behind a continuous miner. At this mine, the continuous miner was restricted to making 20 foot cuts into the coal seam, this required five foot roof bolt intervals.

continued observations.

It was noticed during the second week into phase two, at the beginning of a Saturday shift, that the fire boss provided one of the miners with specific directions to a simple routine task. He was reminded by the principle of his role in the shared leadership structure, and quickly remembered to provide fewer specific instructions. His reminder was taken well, this pattern of deviating from the intervention continued through phase two without continuous observations because miners schedules were not consistent as they were using up year-end vacation. The fire boss frequently returned to his pace-setting methods of leadership throughout phase two, because the section was still behind schedule and being pushed by mine management to increase production.

As phase two continued, part of the crew used the learning material, coaching, instructional time, and reorganization as an opportunity to improve themselves. Down time was a pivotal middle ground for development during the intervention, as some miners utilized their discretion to complete tasks normally left to the next shift or to avoid work. Overall, the crew members reported that they were functioning better as a team and that individual miners were more willing to jump in and help each other. Though unity and cohesion improved, there was a consensus among the miners that the overall attitude towards work and the company showed no significant change.

The foreman and fire boss were impressed with the overall improvement in performance in the section, but mentioned that some miners were not interested in taking on the leadership principles, and that individual discretion and authority to make decisions provided an excuse for some miners to get out of completing routine tasks.

6.2 Analysis of Surveys and Hypothesis$_0$

The miner survey was distributed at the beginning, middle, and end of the intervention. The principle investigator administered the beginning and middle surveys, and the section foreman administered the postintervention survey. After completion of the surveys, each miner returned the survey in a Manilla, nontransparent folder, which was collected and filed by the principle investigator. The situational safety awareness survey required more time for completion. For this reason, it was collected only two times, pre-and postintervention.

In the analysis of these responses, a table is provided for each category, according to the hypothesis. Tables show the number of participants and their responses according to the five-point Likert scale (1=strongly disagree, 2=disagree, 3=neutral, 4=agree, 5=strongly agree). Radar plots and other graphs are also provided to show changes in uniformity of responses, as well as increases and decreases of perception.

6.2.1 Shared Leadership

Because the number of participants was small (N=9), responses could not be validated with statistical analysis. The data are still useful in observing some changes in overall perception, which was intended to determine effectiveness in implementing the shared leadership structure. Table 6.1 is a record of responses from both crews showing a mean for each response. Figure 6.1 is a graph of the responses from the intervention crew. Figure 6.2 is a graph of responses from the nonintervention crew. Red bars represent an increase on the five-point Likert scale and black bars represent a decrease.

The decrease in perception of shared leadership indicates that the intervention was not effectively implemented; see Figure 6.1. As mentioned in section 6.1, the intervention

crew was mining on a section that was 4,500 feet behind schedule, next in sequence for the longwall, and in need of small unit leadership. The increased pressure to meet production goals and overcome leadership deficiencies was a prohibiting factor.

Considering the positive reception to the intervention training, the larger decrease in perception of shared leadership in the intervention crew over the nonintervention crew could prove that miners were more aware of the decision-making processes occurring in their section, even though they did not participate as intended in those processes; see Figures 6.1 and 6.2. The conclusion includes an elaboration on the possibility of a type II error in the statistical analysis as well as other factors which indicate positive changes in shared leadership.

6.2.2 Leadership Climate

The five subcategories in the leadership climate construct included, trust, communication, task proficiency, dependability, and accountability. The questionnaire contained two to eight questions per item and quantified each item on a five-point Likert scale. Because the sample size is small (N=9), a more detailed analysis is provided per question used on the survey, rather than any descriptive statistics. A radar plot of survey responses to each of these categories, displays the uniformity of survey responses, with the control crew and intervention crew side-by-side; see Figures 6.3 – 6.5. The preintervention responses are labeled with a light blue color, midintervention with orange, and postintervention with grey. The mean Likert score for each question over the group of surveys (pre-, mid-, and postintervention) is useful in assessing small changes in perception. However, the small sample size correlates to higher standard deviation per each question, which prohibits validation of responses using descriptive statistics.

Reference Table 6.2 for an overview of the intervention crew statistics and Table 6.3 for an overview of the nonintervention crew statistics.

The radar plot is effective for displaying uniformity, or the lack thereof, as it expands, contracts, or scatters. With attention to the demeanor of the question, a positive change can be observed with an expansion or contraction of the grey-colored line in each plot in comparison to the blue line. It is also useful to look for changes in shape (i.e., preintervention responses shaped like a triangle with postintervention responses shaped like a circle), to observe any crew-wide consensus of leadership perception. For example, a circle with points along the outside ring of the radar plot indicates that all of the crewmembers have the same perception regarding that particular question.

6.2.2.1 Trust

The perception of trust decreased in the intervention crew (3.67-3.41), while increasing slightly in the nonintervention crew (3.84-3.85). Trust in the direct supervisor increased slightly (2.89-3.00) in the intervention crew. Without validation of the perception survey because of the sample size, it is difficult to render a strong conclusion strictly from this aspect of leadership climate. See Tables 6.2 and 6.3; also see Figures 6.3-6.5.

In reference to the intervention journal, it was noted that some crew members were discouraged due to a lack of direction and feedback from the section foreman, and showed some level of distrust before the intervention. Section miners were asked to rate their own strengths and weaknesses along with the strengths and weaknesses of their peers in a 360° feedback exercise, based on vision, core values, and goals agreed upon as a crew (see Figure 6.6). While the vision and values were useful to miners in completing

personal action plans, the 360° feedback exercise did not render any useful information as responses were uniform and no comments were provided.

6.2.2.2 Proficiency

Again, there is an overall decrease in perception of proficiency among members in the intervention crew, between the preintervention and the postintervention surveys (3.93-3.48); see Tables 6.2 and 6.3. In the nonintervention crew, there is a .03 increase (3.67-3.70). On the radar plot, there is not only a change in the shape of responses, but the size of the radar plot shrinks between the preintervention and postintervention surveys, resembling a decrease in the overall perception of proficiency; see Figures 6.7 and 6.8.

The questions not only addressed proficiency at the individual level, but also inquired if there was encouragement from supervisors or managers to become more proficient. This is a good representation of the leadership climate as a whole, because this encouragement can come from upper management or from among peers.

6.2.2.3 Dependability

There was a relatively uniform perception of dependability among members in both crews. The 360°-feedback exercise encouraged crew members to take a closer look at their own strengths and weaknesses (see Figure 6.9), as well as other crew member's strengths and weaknesses regarding leadership, the established sets of values and goals, and their overall proficiency at work. The intervention crew indicated a completely uniform perception of familiarity with the strengths and weaknesses of other members in their crew after the intervention; see Figure 6.10.

6.2.2.4 Accountability

Part of the training in the "Miners Guide to Shared Leadership" included an explanation of the difference between accountability and responsibility. Responses to the questions regarding accountability indicated a slight decrease in perception of accountability in both crews; see Figures 6.11 and 6.12.

6.2.2.5 Leadership Climate Summary

The definition of leadership climate has not been well defined in literature. It could be that the definition sits more respectively under organizational culture. For the purposes and scope of this study, the leadership climate construct included communication, trust, proficiency, dependability, and accountability. All of these hold an independent definition and can be found in various categories of literature, but also function well together when using the trait theory of leadership to define suitable competencies for underground miners. As mentioned in the introduction, the trait theory is an efficient method of introducing fundamental leadership principles, but a potential step backwards for groups with well-established leadership structures (i.e., the military). In accordance with the miner survey, both crews indicated a slightly decreased perception of overall leadership climate, though the intervention crew showed more of an overall decrease, except for the measurement of dependability, a (.1) increase; see Figures 6.13 and 6.14. The nonintervention crew showed a .03 increase in proficiency.

6.2.3 Psychological Empowerment

The psychological empowerment construct consists of (a) impact, i.e., degree to which an employee feels his or her work effects an organization, (b) competence, i.e.,

perceived ability to accomplish work-related task, (c) meaningfulness, i.e., intrinsic caring about work task, (d) choice, i.e., perceived self-determination or autonomy (Kirkman and Rosen 1997, 1999; Spreitzer 1995; Thomas and Velthouse 1990).

A sum of the means including all of the items in the psychological empowerment construct, i.e., impact, competence, meaningfulness, and choice indicated an overall decrease in psychological empowerment from the intervention crew (.14), and a slight overall decrease in the nonintervention crew. The intervention crew did indicate an increase in impact (.26), and the nonintervention crew indicated a slight increase in competence (.15); see Figures 6.15 and 6.16.

6.3 Analysis of Surveys and Hypothesis H_1

H_1: An increase in psychological empowerment correlates positively to a change in productivity, perception towards safety and situational awareness among individual miners in an underground coal mining section.

6.3.1 Productivity

Production in tons per hour of run time decreased gradually over the life of the intervention; see Figure 6.17. Typically, on days when a drastic decrease in production was observed, there were additional tasks that took priority over production, such as maintenance on downed equipment. This was the case for both the intervention and nonintervention crews; see Figures 6.18 and 6.19.

Production in tons per shift slightly increased just past the midpoint of the intervention, then dropped significantly at the very end; see Figure 6.19 for details. It is likely that this was affected by the year-end schedule reorganization, holidays, and

encouragement from management to use up remaining vacation days.

Production in tons per shift for the nonintervention crew showed some increase just past the mid-intervention time frame and then decreased; see Figure 6.19. This trend is similar to the intervention crew and likely also corresponds to year-end vacation consumption and holiday shut downs.

Production in tons per hour of run time gradually increased for the nonintervention crew, then slightly decreased towards the end of the study; see Figure 6.20. No trend is visible during the intervention that shows any significant increases or decreases from normal production rates, except for the obvious holiday breaks.

6.3.2 Safety

Because the mine had implemented a successful behavior based safety program over the last decade, certain questions deem a programmed response. Deviations from these expected normal responses that would normally reassure the positive safety culture of the section resemble holes in what is thought to be a strong safety culture; see Figures 6.21-6.28 for a radar plot of survey question responses regarding safety. Responses to these questions do not represent a mine consensus, but are insightful to the actual safety culture of the section. Responses overall, indicate some positive changes in perception of safety among the intervention crew members; see Figure 6.29, and an overall decrease in perception of safety among the nonintervention crew members; see Figure 6.30. There was a significant increase in the perception of miners in the intervention crew taking responsibility for their own safety. A larger sample size would permit certain regression methods to determine any correlation to the leadership competencies learned during the intervention.

6.3.3 Situational Awareness

Safety and situational awareness were measured before and after the intervention. Because the measurement tool required a significant amount of time to complete, a mid-intervention measurement was not taken. In each graph, Group A represents the pre-intervention survey responses and Group B represents the postintervention responses. The surveys were completed with pencil and paper underground, then input to survey calculator provided by Psyfactors, Ltd. This measurement tool is intended for use in both discerning current employee competencies and as a prescreening for potential employee competencies, using the criterion in red as a guideline.

The instrument was useful for the study, but intended for personnel seeking employment, and thus, different attitudes. The survey was long and incorporated questions requiring pattern recognition and memory skills to measure perception and comprehension. It was observed that some miners lost interest in the content and gave minimal effort to completing the survey, knowing that there was no benefit to providing correct responses, see perception and comprehension in Figure 6.31. This pattern occurred in responses from both the intervention and nonintervention crew.

The assessment for the nonintervention crew indicated some significant increases in mental alertness and safety self-awareness. There were slight increases in managing fatigue, responsibility for safety, safety conscientiousness, and team and road safety orientation. There was a significant decrease in perception and comprehension, defensive safety habits, and general hazard awareness; see Figure 6.32.

Responses to the Situational Safety Awareness Assessment in the intervention crew indicated a slight decrease in the average level of situational awareness and safety,

though there was significant increase in the category of perception and comprehension and, a slight increase in defensive safety habits; see Figure 6.33.

Responses to questions regarding situational awareness on the miner survey indicated a slight positive change in routine anticipation of failures for the intervention crew; see Figure 6.33 and Table 6.4. There was a slight decrease in perception of situational awareness among members in the nonintervention crew, regarding awareness of the worst possible risk in the mining section; see Figure 6.34. In general, the responses indicated a slight change for one of the questions, and no change regarding situational awareness overall.

Table 6.1 Survey Questions and Responses Regarding Shared Leadership

Questions	Preintervention		Midintervention		Postintervention	
Intervention Crew		AVG		AVG		AVG
Miners in my crew make decisions regarding what needs to get done.	4 4 4 4 5 5 4 4 3	4.11	4 3 3 3 4 4 4 3 1	3.22	3 4 4 3 4 4 4 3 2	3.44
Miners work alone with supervision for the majority of their work shift.	5 2 4 2 4 5 2 4 4	3.56	4 3 3 4 2 - 3 4 4	3.38	2 2 4 4 5 4 2 3 3	3.22
Miners in my section make decisions regarding how things should get done.	4 3 4 4 4 5 4 4 3	3.89	4 1 3 3 4 3 4 3 2	3.00	2 3 4 3 4 4 4 4 2	3.33
Miners in my section make decisions regarding when things should get done.	4 3 3 4 4 4 4 4 4	3.78	4 3 3 4 4 3 4 4 4	3.67	4 3 4 4 4 4 4 4 4	3.89
Decisions that I make benefit my crew.	4 4 4 4 4 4 3 5 4	4.00	4 3 3 4 2 3 4 3 2	3.11	2 2 4 4 3 4 4 4 2	3.22
Miners in my crew are comfortable making decisions	4 4 3 4 4 4 4 4 4	3.89	3 3 4 4 2 4 3 2 2	3.00	3 3 3 3 3 4 2 3 2	2.89
My direct supervisor makes all the decisions.	2 2 3 2 2 2 2 2 2	2.11	2 4 2 3 2 4 3 2 2	2.67	3 3 2 4 3 2 2 2 4	2.72
My direct supervisor is comfortable with change	2 3 2 2 3 3 3 2 4	2.67	2 2 3 3 4 4 2 4 2	2.89	3 4 2 2 2 3 2 4 2	2.67
I influence the other miners in my section.	4 4 3 4 4 4 4 4 4	3.89	4 3 3 5 4 3 4 3 5	3.78	4 2 3 3 4 4 4 4 4	3.56
Questions	Preintervention		Midintervention		Postintervention	
Nonintervention Crew						
Miners in my crew make decisions regarding what needs to get done.	2 4 4 4 5 4 5 5 3	4.00	4 4 3 2 3 4 5 3 5	3.67	3 4 3 4 4 2 4 3 4	3.44
Miners work alone with supervision for the majority of their work shift.	4 4 3 4 4 3 2 2 2	3.11	3 3 4 4 3 3 4 3 2	3.22	3 4 3 4 3 2 4 3 3	3.22
Miners in my section make decisions regarding how things should get done.	4 4 3 4 4 3 5 3 4	3.78	4 4 4 3 3 4 4 4 4	3.78	3 4 3 4 4 2 4 4 4	3.56
Miners in my section make decisions regarding when things should get done.	4 4 4 4 3 3 4 3 5	3.78	4 4 4 4 4 3 4 4 5	4.00	3 4 4 4 2 2 3 5 5	3.56
Decisions that I make benefit my crew.	3 4 4 4 4 3 4 2 4	3.56	4 4 4 4 4 3 3 3 4	3.67	4 3 4 3 4 3 4 3 4	3.56
Miners in my crew are comfortable making decisions	3 2 3 4 4 4 4 4 3	3.44	4 4 3 2 4 4 3 3 4	3.44	4 2 3 3 4 3 4 4 3	3.33
My direct supervisor makes all the decisions.	2 3 3 4 2 3 5 3 2	3.00	2 2 4 3 4 2 3 3 3	2.89	3 3 3 3 2 - 2 3 2	2.63
My direct supervisor is comfortable with change	3 2 3 3 4 3 3 5 4	3.33	4 3 4 2 2 4 3 3 4	3.22	3 3 3 3 3 4 3 3 3	3.11
I influence the other miners in my section.	3 5 5 4 2 3 3 4 5	3.78	4 3 3 4 3 2 4 5 5	3.67	3 4 3 4 2 3 3 5 5	3.56

Table 6.2 Intervention Crew Questions and Responses Regarding Leadership Climate

Intervention Crew																								
Communication										AVG										AVG										AVG
My direct supervisor and I communicate well.	3	3	3	2	2	4	4	4	4	3.22	2	3	3	1	2	4	3	3	2	2.56	1	4	2	4	3	4	2	4	3	3.00
Miners understand what their supervisor expects of them in this section.	4	4	1	4	3	4	4	4	3	3.44	3	3	3	3	4	4	4	3	4	3.44	2	4	4	4	4	4	4	3	2	3.44
Miners receive regular feedback and coaching from supervisor.	2	1	1	2	2	4	2	2	4	2.22	3	2	2	1	2	3	2	3	2	2.22	1	2	2	2	3	3	2	4	2	2.33
The feedback and coaching received from my supervisor is effective.	3	1	1	2	2	4	2	3	4	2.44	3	3	2	1	2	3	3	3	2	2.44	1	2	3	2	3	3	2	3	2	2.33
Concerns and suggestions are communicated to management when appropriate.	3	3	4	2	4	4	3	3	4	3.33	2	3	3	1	2	4	3	4	2	2.67	4	3	2	3	3	3	2	4	2	2.89
Miners effectively communicate with each other in my section.	3	4	4	2	4	5	4	3	4	3.67	4	3	5	4	4	4	3	3	4	3.78	4	4	3	3	4	4	4	3	4	3.67
My direct supervisor keeps miners informed of activities and changes at this mine.	3	3	1	2		4	2	4	4	2.88	4	3	3	1	2	4	3	3	1	2.67	1	2	3	3	2	3	2	3	2	2.33
Trust																														
I trust my direct supervisor.	3	3	2	3	2	2	2	5	4	2.89	3	3	3	1	3	2	3	4	2	2.67	1	2	2	4	4	3	4	4	3	3.00
Team work is valued to get things done in my section.	5	4	3	4	4	5	4	4	4	4.11	4	3	4	4	4	4	5	2	4	3.78	3	3	4	4	4	4	4	2	4	3.56
I trust the miners in my crew.	4	4	4	4	5	5	4	3	3	4.00	4	5	4	5	4	5	4	3	3	4.11	4	4	4	4	4	5	4	2	2	3.67
Proficiency																														
Miners in my section are encouraged to find better wats to do things.	4	4	1	4	3	4	4	4	4	3.56	2	1	4	3	2	2	4	4	2	2.67	3	3	4	3	3	3	4	4	2	3.22
Miners in my crew are knowledgeable about their job.	4	4	5	4	4	4	4	4	4	4.11	4	4	3	5	4	5	4	4	4	4.11	4	4	4	4	4	4	4	4	4	4.00
Miners in my section are proficient at their job.	4	4	5	4	5	4	4	4	3	4.11	4	4	4	4	4	4	4	3	3	3.78	4	3	4	3	4	4	2	3	2	3.22
Dependability																														
My crew members can depend on me.	4	2	5	4	5	4	4	5	5	4.22	4	4	3	5	4	4	4	4	4	4.00	4	3	4	5	4	4	4	5	4	4.11
I am familiar with the strengths and weakness of my crew members.	2	3	4	5	3	4	4	4	4	3.67	4	4	3	4	4	4	5	4	4	4.00	4	4	4	4	4	4	4	4	4	4.00
Accountability																														
I am held accountable for my responsibilities.	5	4	4	4	4	4	4	4	1	3.78	4	4	4	5	4	4	4	2	4	3.89	4	3	4	4	4	4	4	2	4	3.67
Everyone in my section is held accountable for their responsibilities.	4	4	2	4	3	4	3	3	2	3.22	4	4	3	4	4	2	4	2	2	3.22	3	3	4	4	2	3	2	2	2	2.78

Table 6.3 Nonintervention Crew Questions and Responses Regarding Leadership Climate

Nonintervention Crew																								
Communication										AVG										AVG										AVG
My direct supervisor and I communicate well.	5	5	4	3	4	3	5	5	4	4.22	4	4	4	4	4	3	5	4	5	4.11	3	4	4	4	3	3	4	4	4	3.67
Miners understand what their supervisor expects of them in this section.	5	4	4	4	4	5	3	5	4	4.22	3	4	4	4	5	3	4	3	4	3.78	4	4	4	4	4	3	4	4	4	3.89
Miners receive regular feedback and coaching from supervisor.	2	4	4	2	3	4	4	4	3	3.33	4	3	4	2	3	3	3	3	4	3.22	3	2	4	3	3	4	4	4	4	3.44
The feedback and coaching received from my supervisor is effective.	3	4	4	3	3	3	3	4	4	3.44	4	3	4	4	4	4	4	3	4	3.78	2	3	4	3	3	3	3	4	4	3.22
Concerns and suggestions are communicated to management when appropriate.	3	2	3	4	4	3	2	5	4	3.33	4	3	2	4	4	3	3	3	4	3.33	4	2	3	4	3	1	2	4	4	3.00
Miners effectively communicate with each other in my section.	3	4	4	4	3	3	3	4	2	3.33	4	4	2	4	2	4	4	3	3	3.33	5	4	3	4	3	2	4	4	4	3.67
My direct supervisor keeps miners informed of activities and changes at this mine.	4	2	4	3	3	4	5	3	3	3.44	4	4	4	2	5	3	3	4	4	3.67	4	4	4	4	4	3	3	4	4	3.78
Trust																														
I trust my direct supervisor.	5	4	4	3	3	2	4		4	3.63	5	3	4	3	3	4	5	4	5	4.00	5	4	4	4	3	4	3	4	4	3.89
Team work is valued to get things done in my section.	4	5	3	4	3	2	4	5	5	3.89	4	4	4	4	2	3	5	3	5	3.78	4	4	4	4	2	4	4	4	4	3.78
I trust the miners in my crew.	4	4	5	4	4	3	3	5	4	4.00	4	3	3	3	5	3	4	5	5	3.89	5	4	3	4	3	4	3	5	4	3.89
Proficiency																														
Miners in my section are encouraged to find better wats to do things.	1	2	3	4	3	4	4	5	4	3.33	4	3	4	3	4	4	4	4	5	3.89	2	4	4	4	4	4	3	4	4	3.67
Miners in my crew are knowledgeable about their job.	3	4	5	5	5	4	3	4	4	4.11	4	4	4	4	5	4	4	4	5	4.22	4	4	4	4	4	4	4	4	4	4.00
Miners in my section are proficient at their job.	3	4	3	4	4	3	3	4	4	3.56	3	3	3	4	4	4	4	4	4	3.67	3	4	3	4	4	3	3	3	4	3.44
Dependability																														
My crew members can depend on me.	4	5	5	5	4	3	5	5	5	4.56	4	4	4	5	5	3	5	4	5	4.33	4	4	4	4	4	4	4	5	5	4.22
I am familiar with the strengths and weakness of my crew members.	4	4	3	4	4	4	4	3	4	3.78	4	3	4	4	2	3	3	5	4	3.56	4	4	3	4	3	4	3	5	4	3.78
Accountability																														
I am held accountable for my responsibilities.	3	3	5	5	5	4	5	5	5	4.44	4	3	5	4	4	4	3	5	5	4.11	3	4	4	4	4	4	3	5	5	4.00
Everyone in my section is held accountable for their responsibilities.	3	2	4	4	4	4	5	3	4	3.67	4	3	5	3	2	3	3	3	4	3.33	3	4	4	4	3	4	3	4	4	3.67

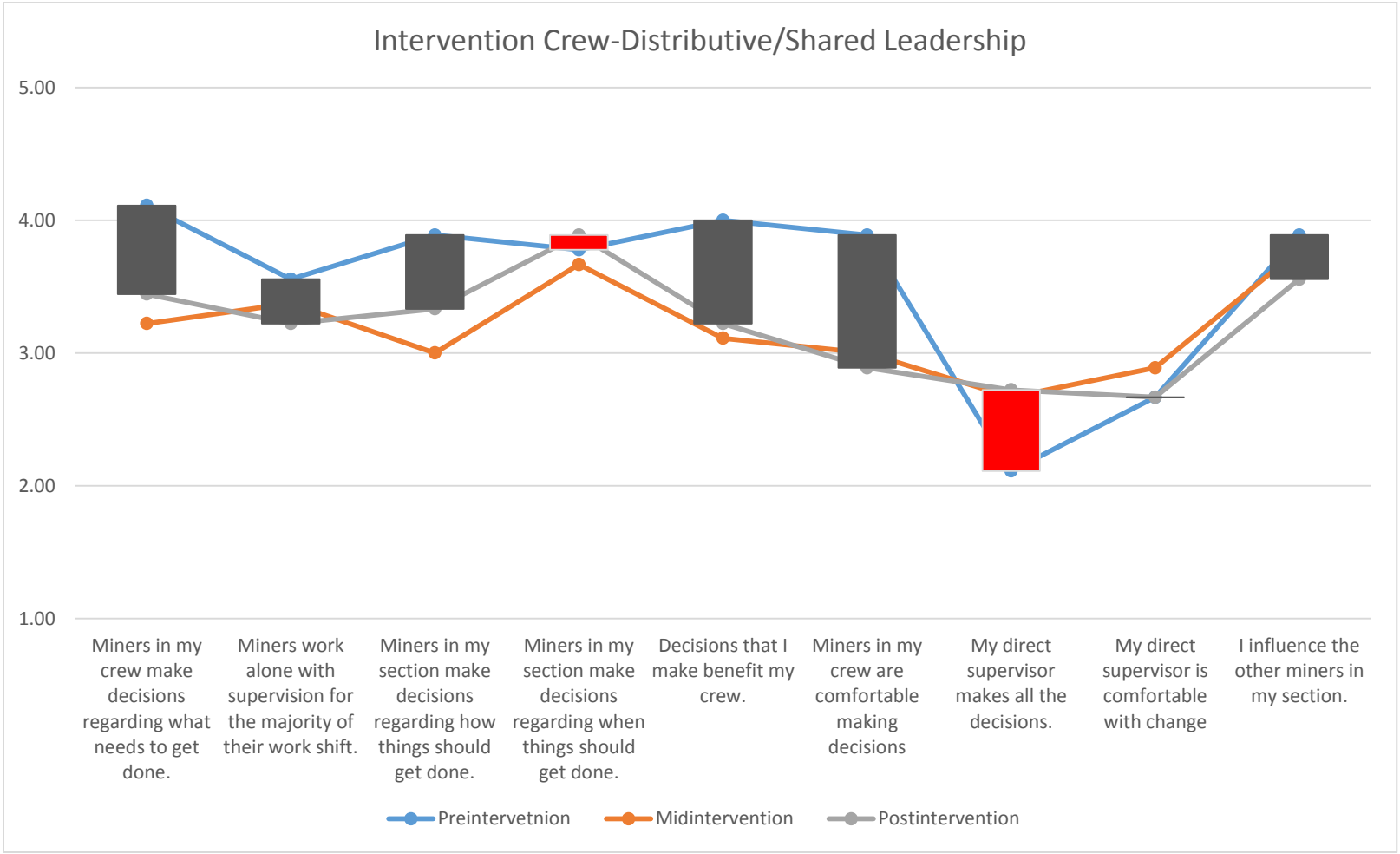


Figure 6.1 Intervention Crew Changes in Perception of Shared Leadership

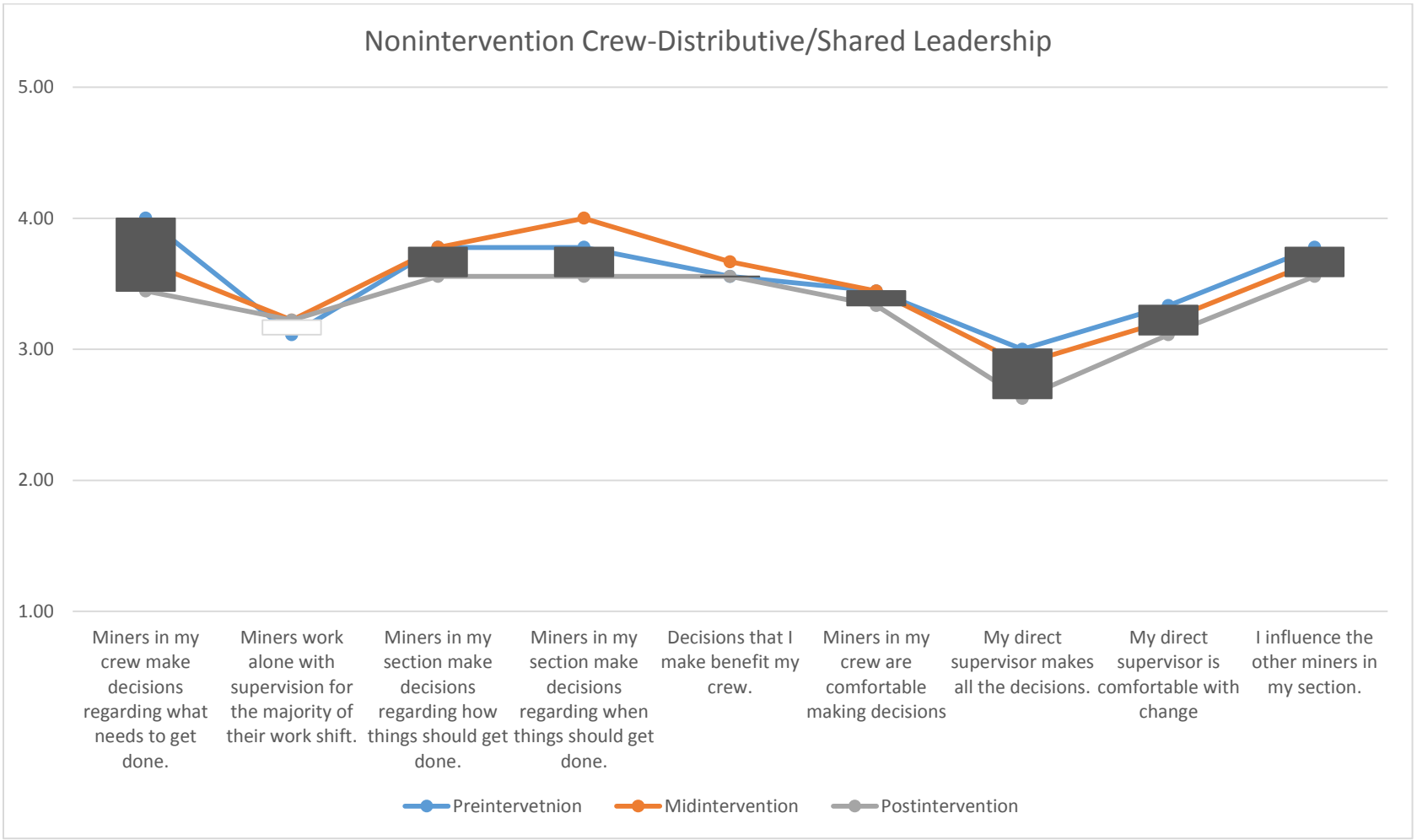


Figure 6.2 Nonintervention Crew Changes in Perception of Shared Leadership

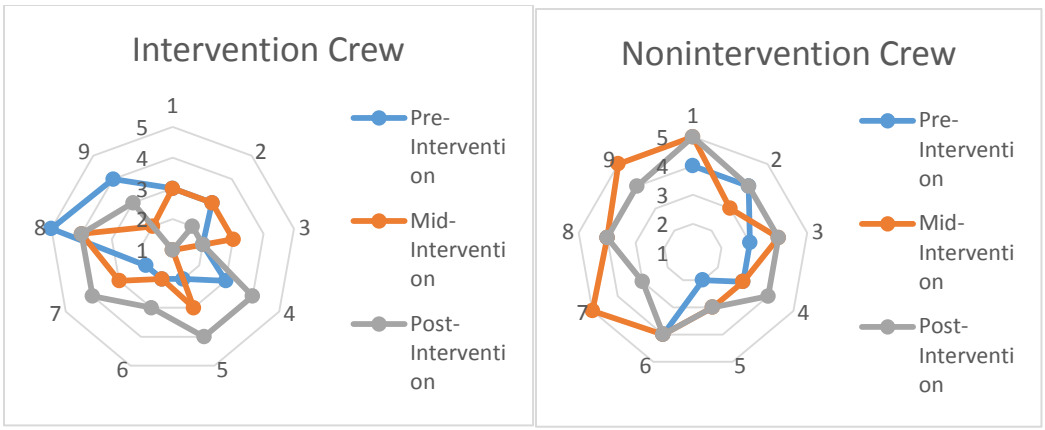


Figure 6.3 I Trust My Direct Supervisor

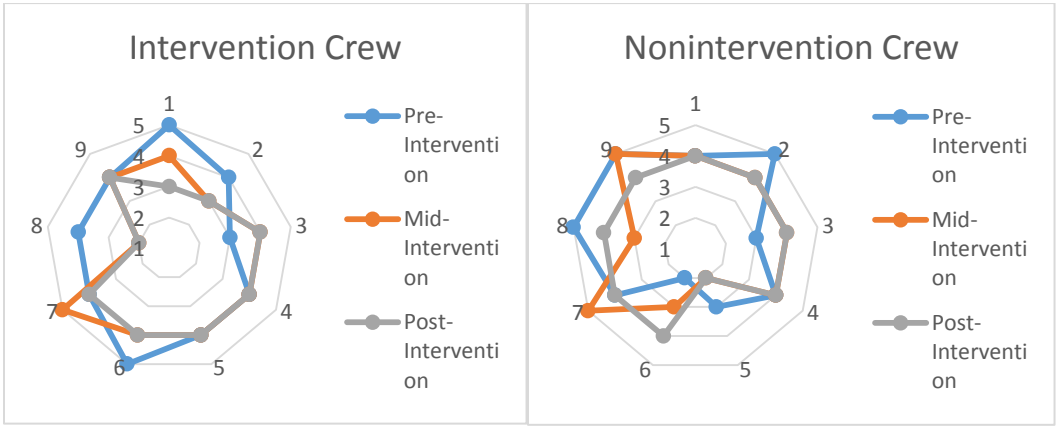


Figure 6.4 Teamwork is Valued to Get Things Done in My Section

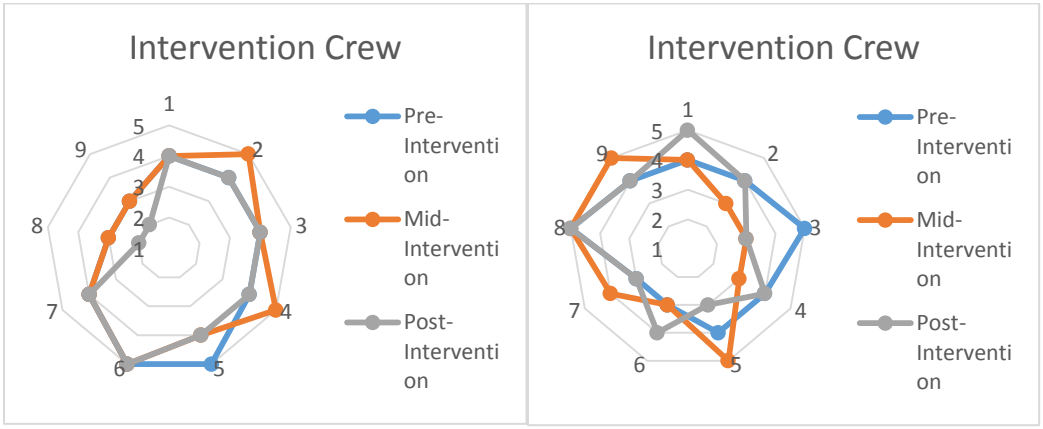


Figure 6.5 I Trust the Miners in My Crew

Vision

This crew will be the safest, well-skilled crew that anyone would want to be a part of.

Values

Always watch out for each other.

Communicate with each other efficiently and effectively.

Always be willing to jump in and help each other out.

Always do the job right.

Keep a positive attitude.

Goals

Safety-No Injuries

Production- Exceed the monthly budget

Leave the section in better condition than it was handed over (Could be a value)

Figure 6.6 Intervention crew vision, values and goals miners pocket card

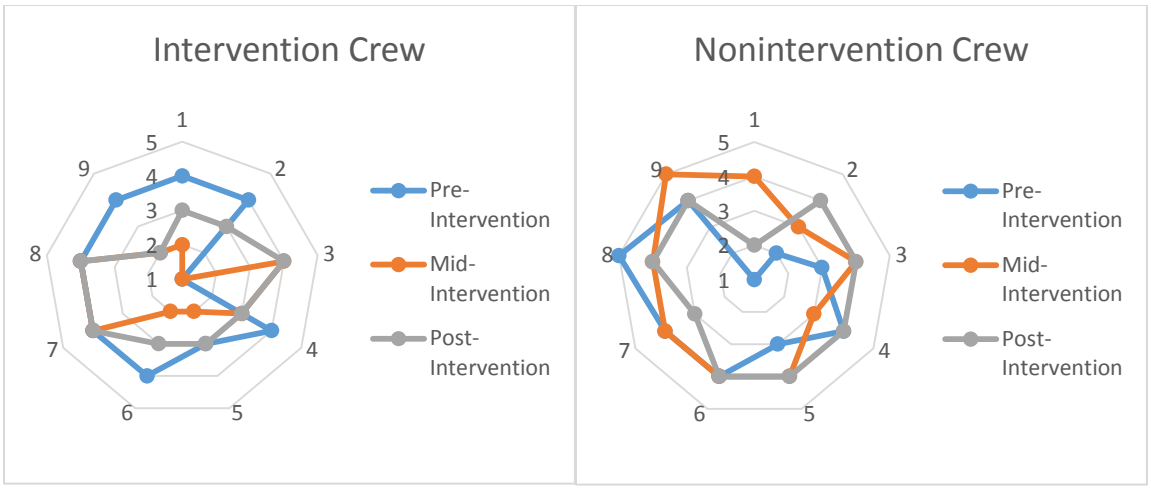


Figure 6.7 Miners in My Section are Encouraged to Find Better Ways to Do Things.

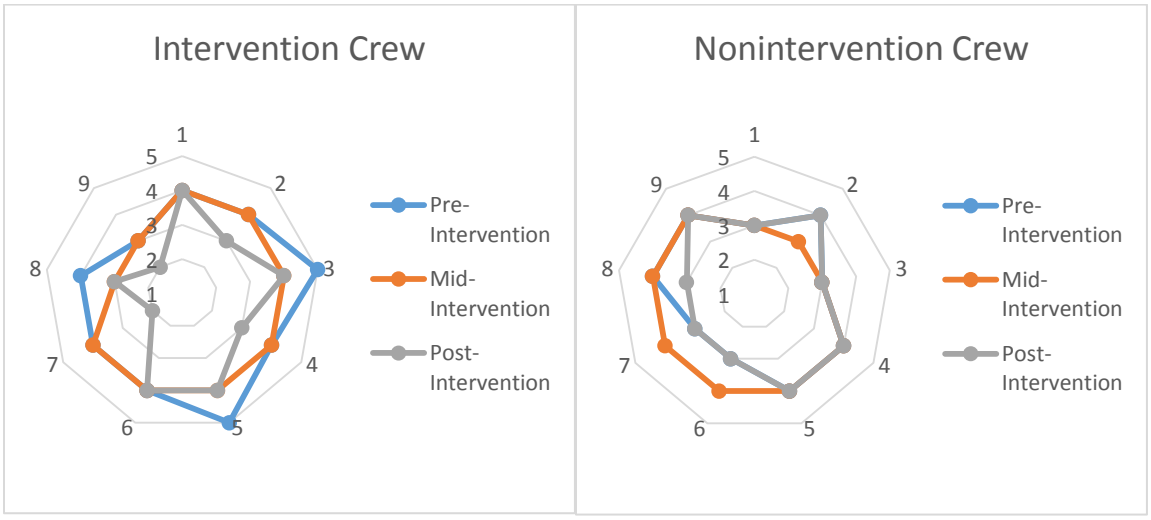


Figure 6.8 Miners in My Section are Proficient at Their Job.

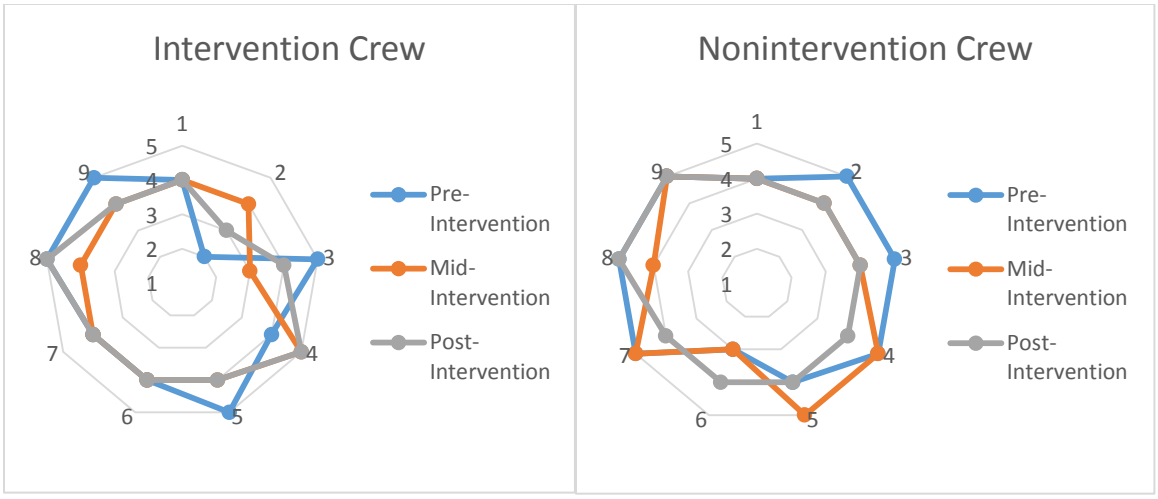


Figure 6.9 My Crew Members Can Depend on Me.

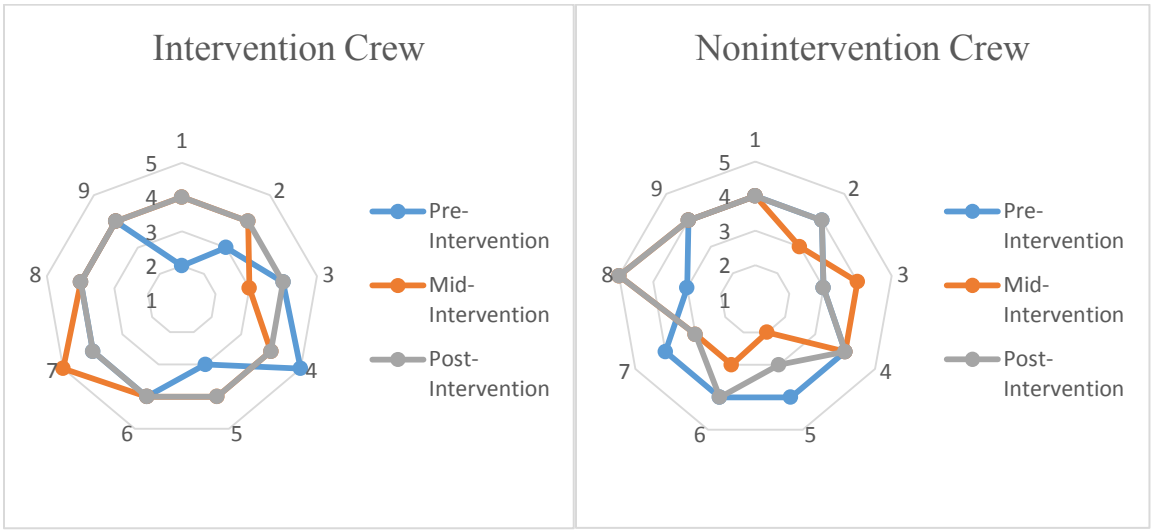


Figure 6.10 I Am Familiar with the Strengths and Weaknesses of My Crew Members.

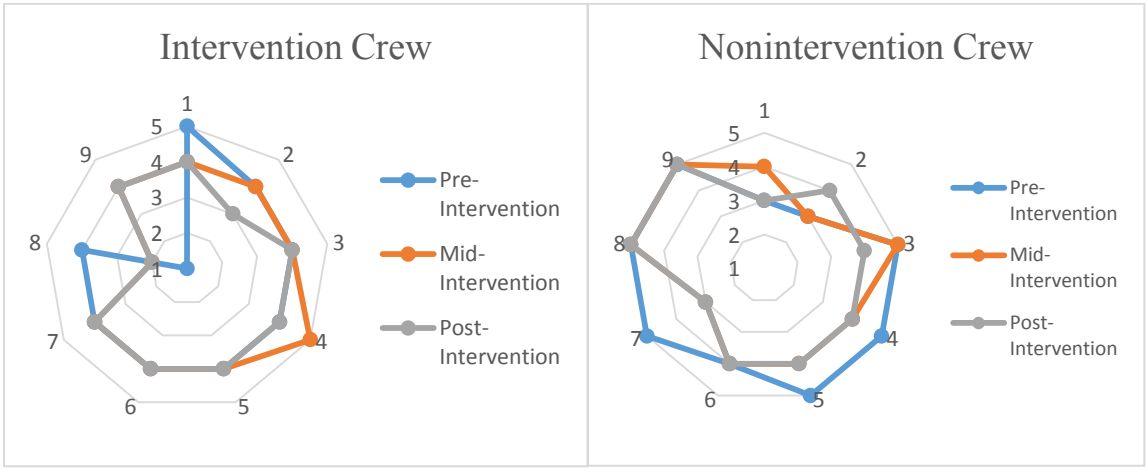


Figure 6.11 I am Held Accountable for My Responsibilities.

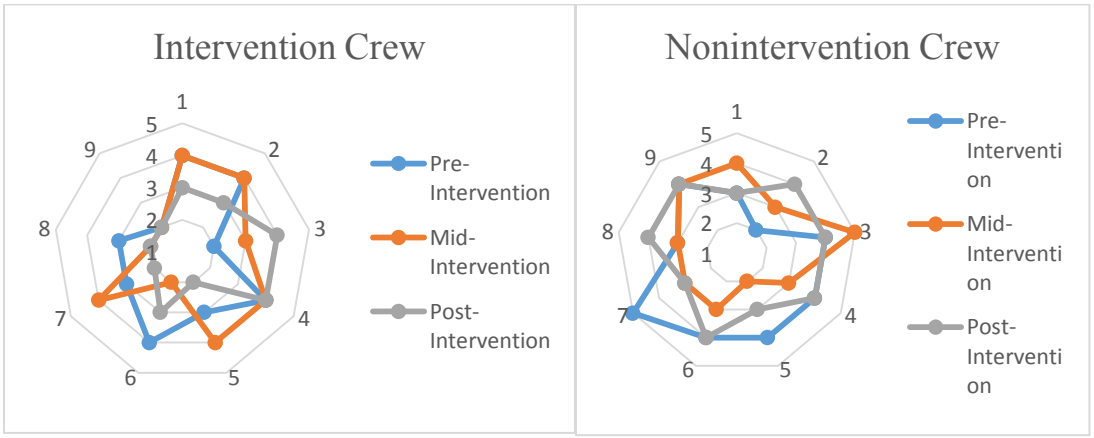


Figure 6.12 Everyone in My Section is Held Accountable for Their Responsibilities.

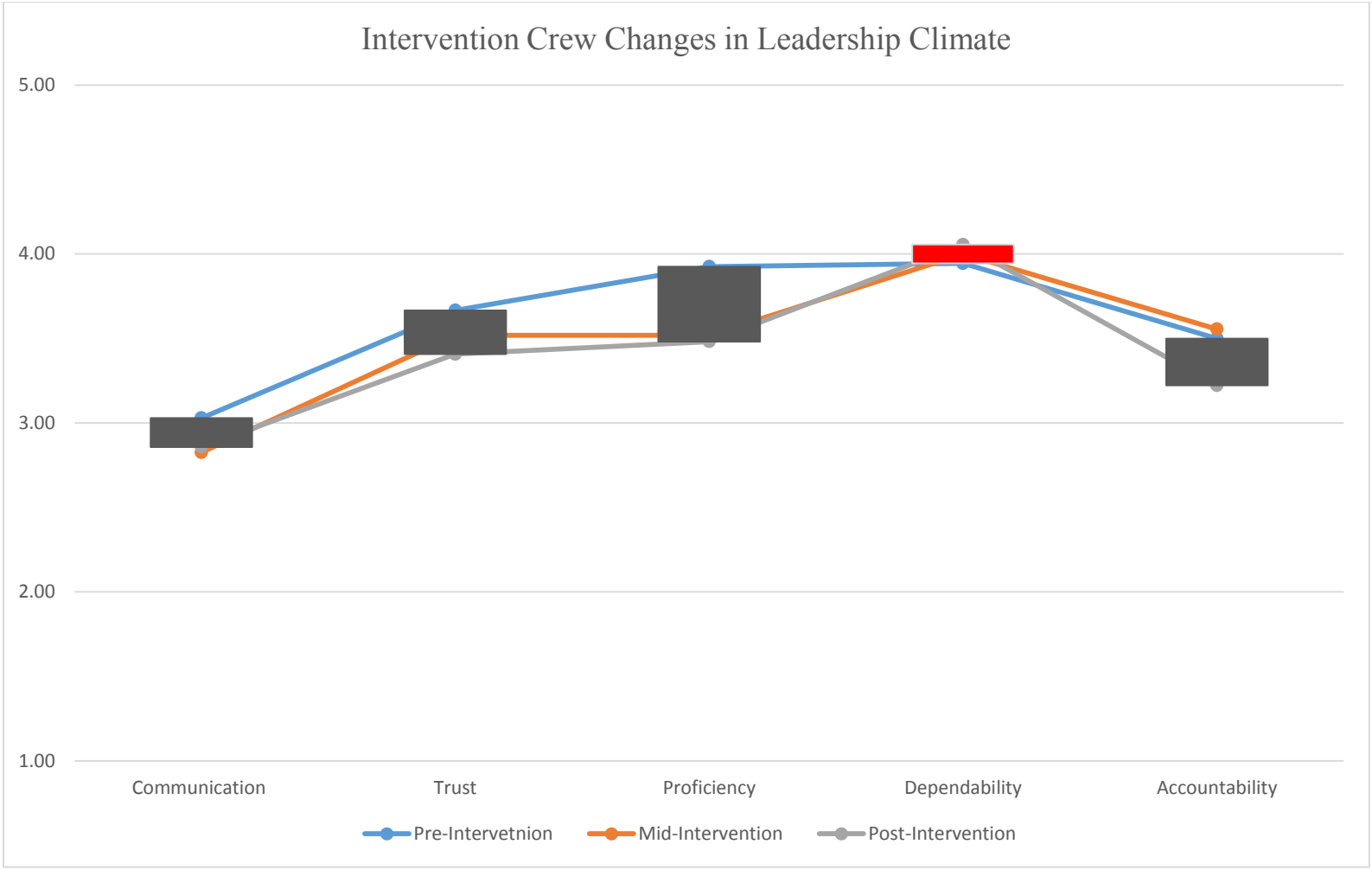


Figure 6.13 Intervention Crew Changes in Leadership Climate

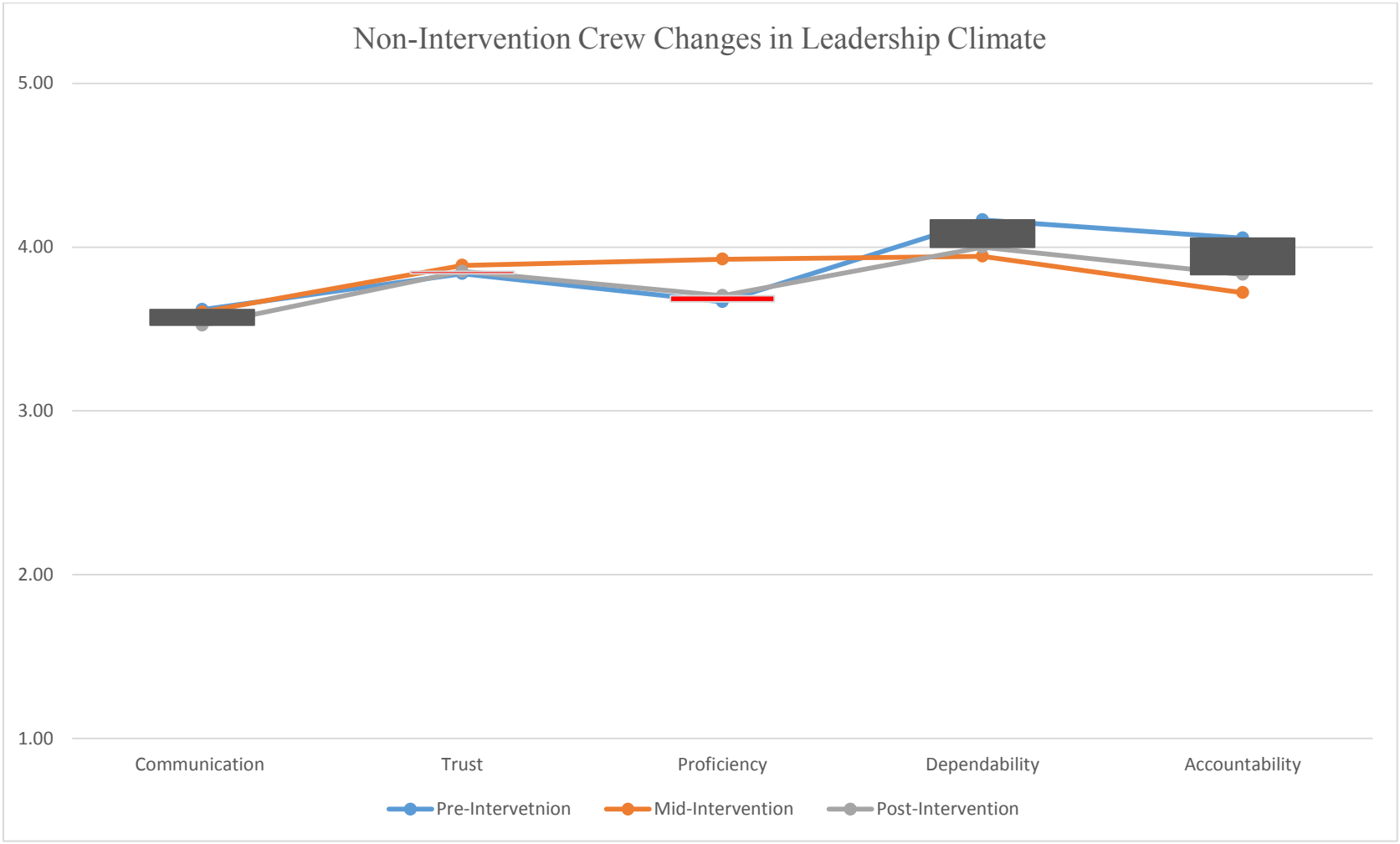


Figure 6.14 Nonintervention Crew Changes in Leadership Climate

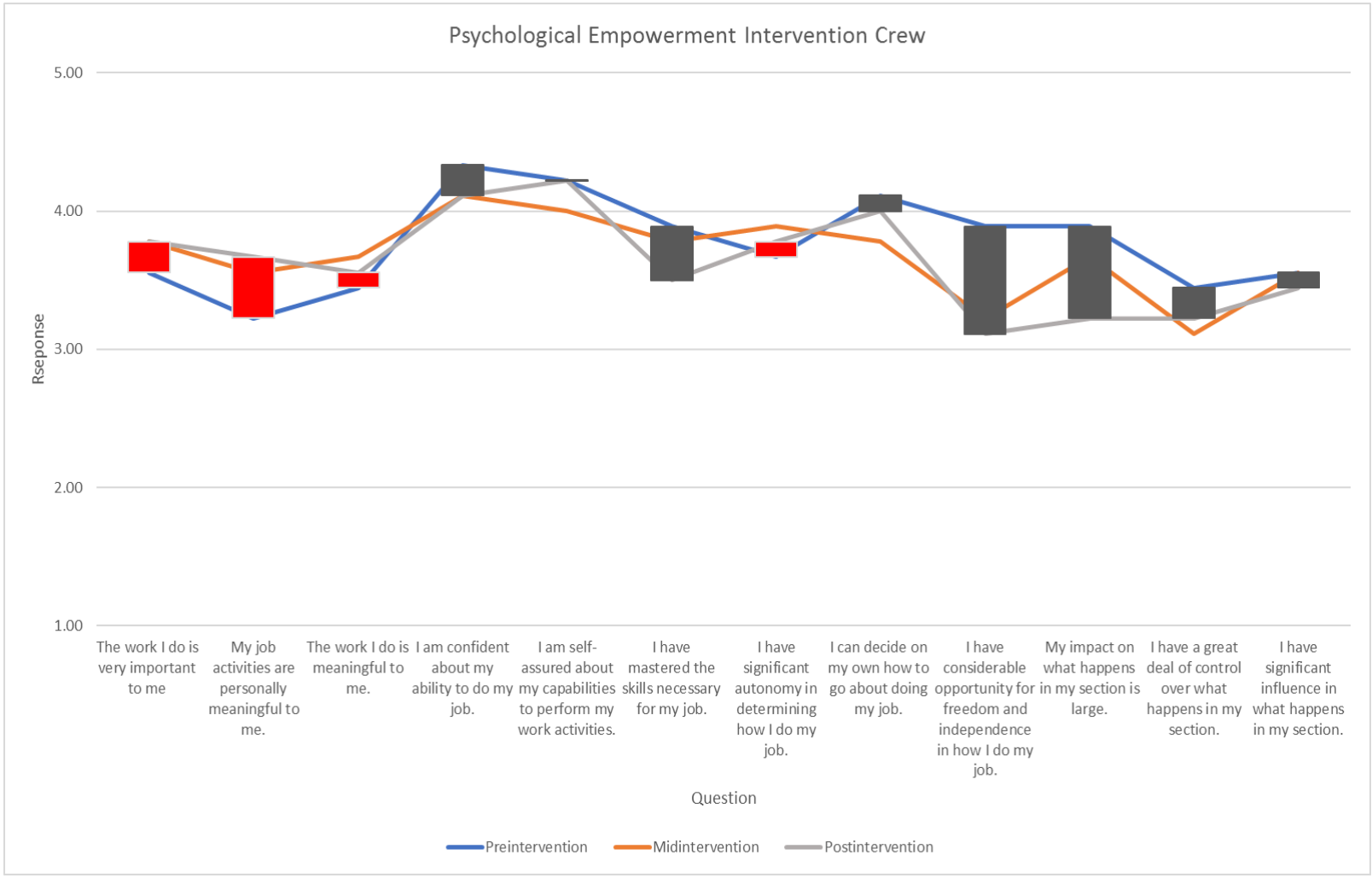


Figure 6.15 Intervention Crew Changes in Perception of Psychological Empowerment

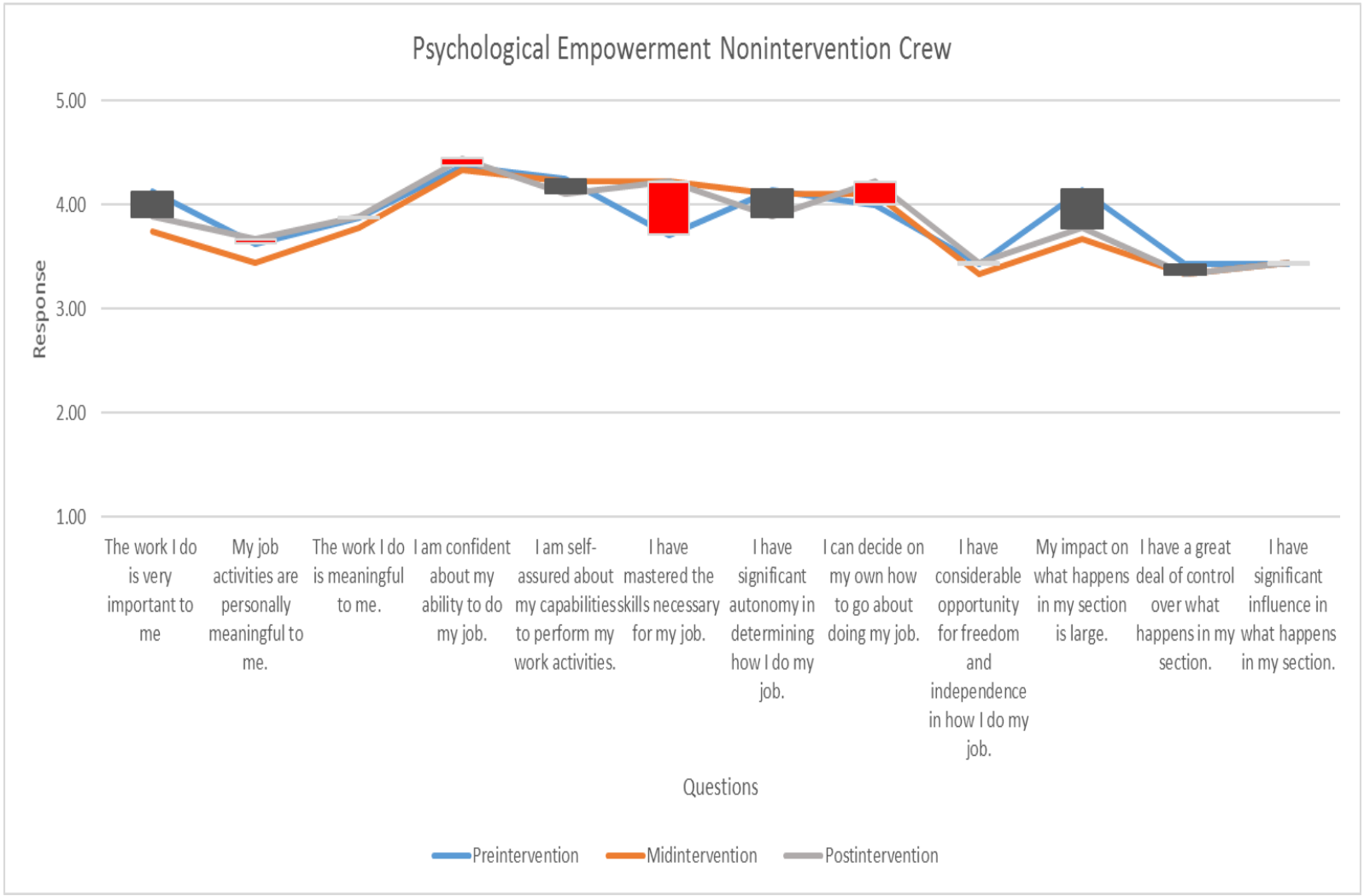


Figure 6.16 Nonintervention Crew Changes in Psychological Empowermen

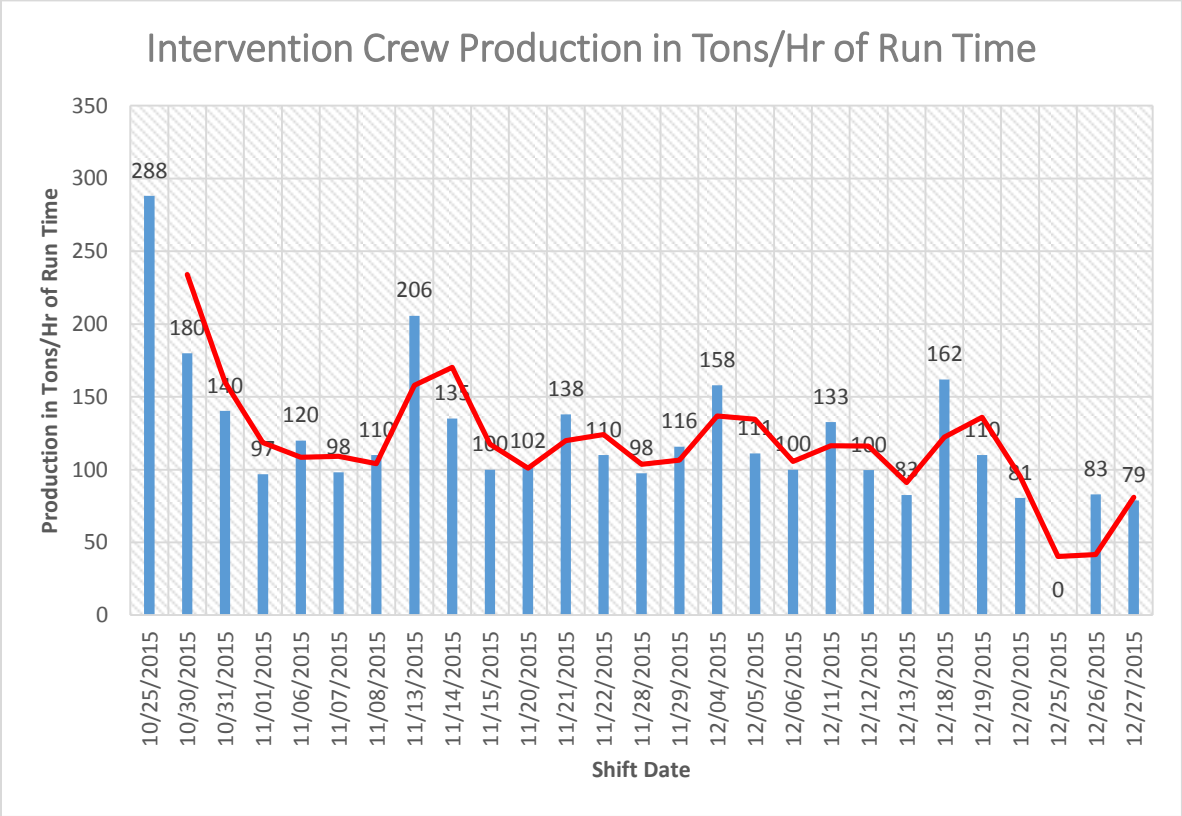


Figure 6.17 Intervention Crew Production in Tons Per Hour of Run Time.

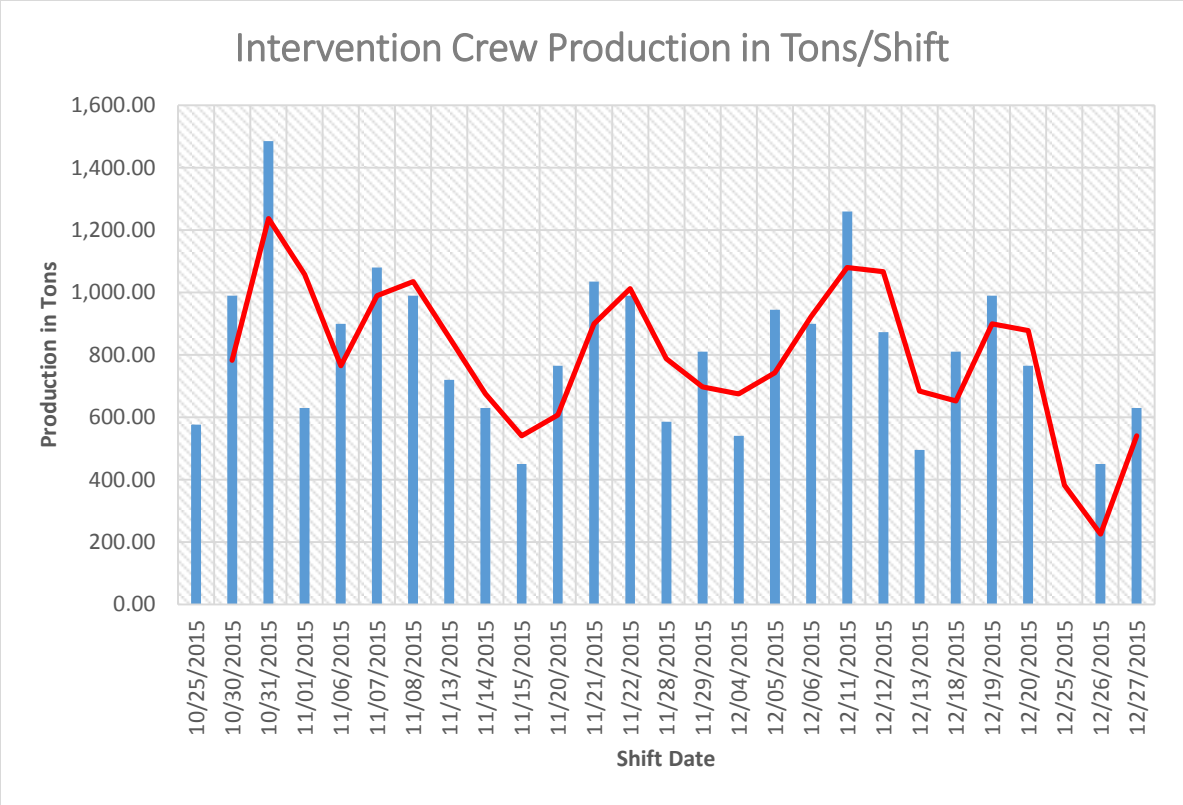


Figure 6.18 Intervention Crew Production in Tons Per Shift

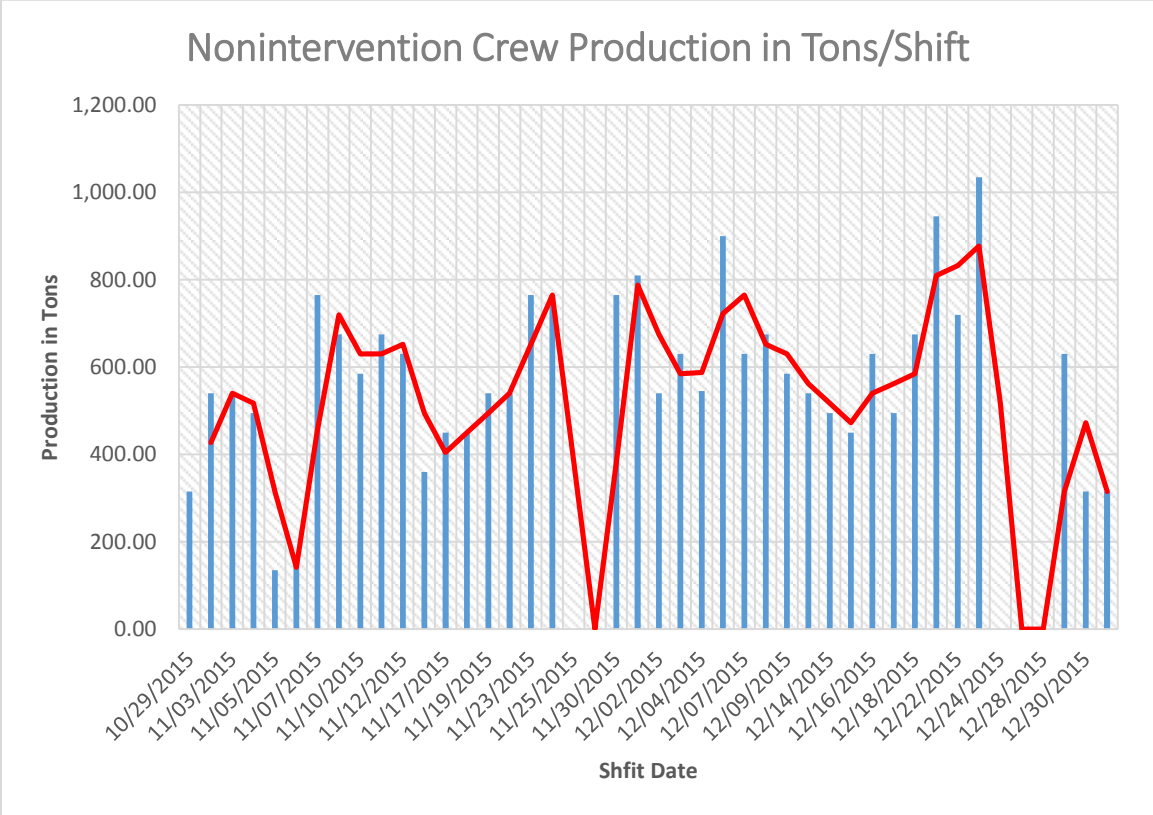


Figure 6.19 Nonintervention Crew Production in Tons Per Shift.

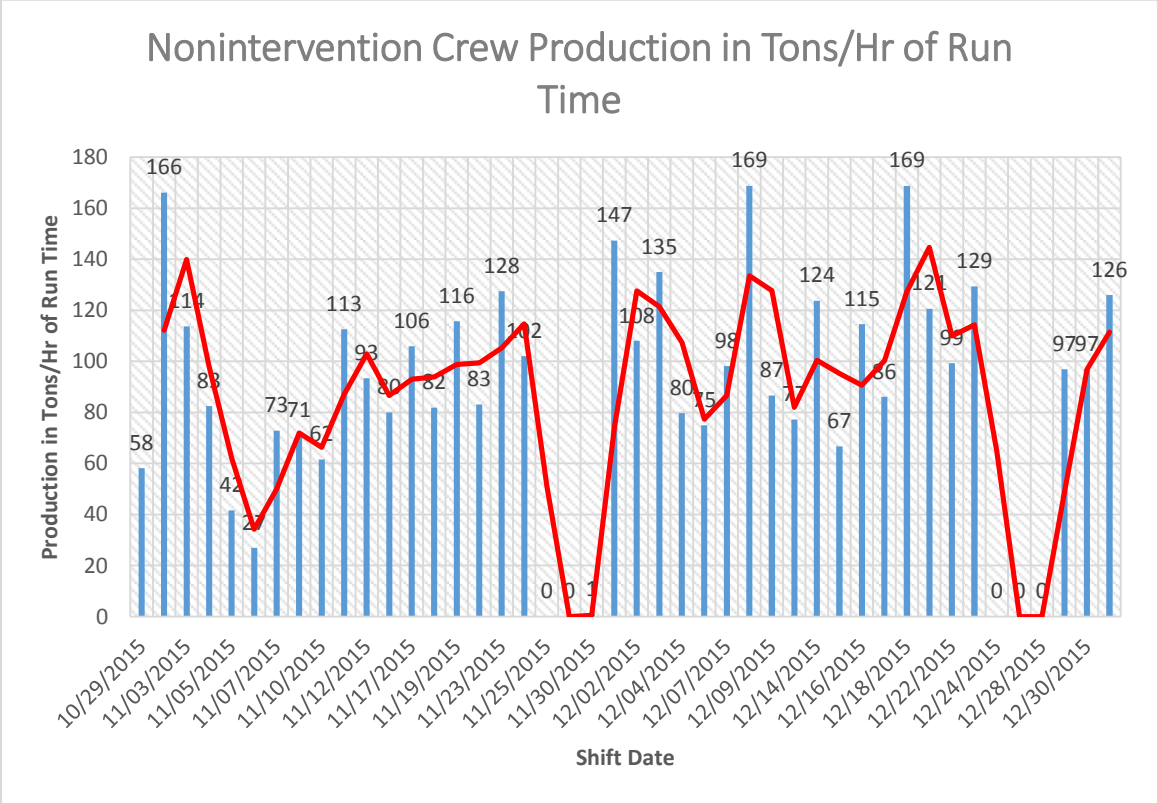


Figure 6.20 Nonintervention Crew Production in Tons Per Hour of Run Time.

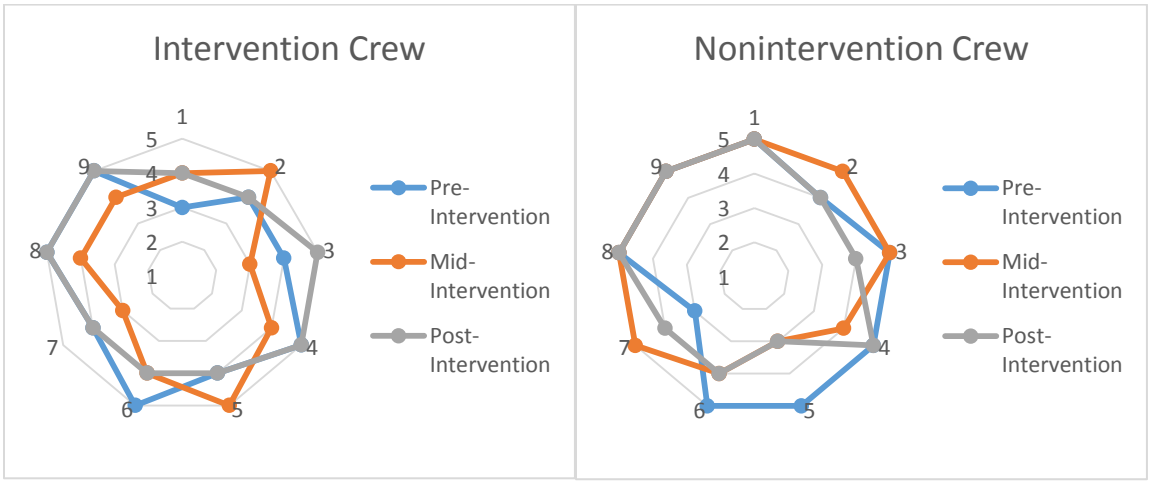


Figure 6.21 Miners Can Shut Down Work if it's Unsafe or if Other Problems Arise.

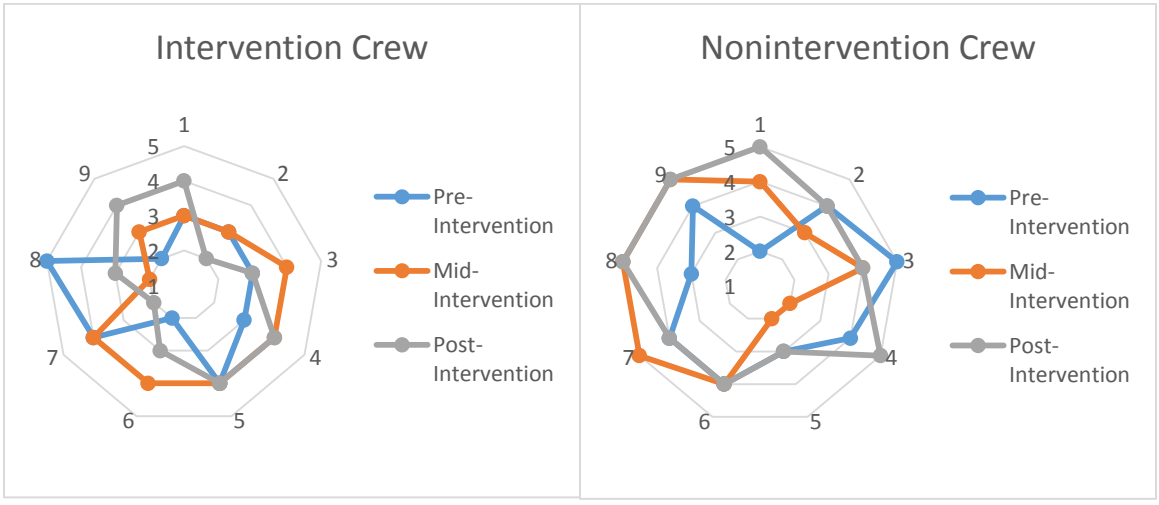


Figure 6.22 Unsafe Acts Are Not Tolerated by Miners in My Section.

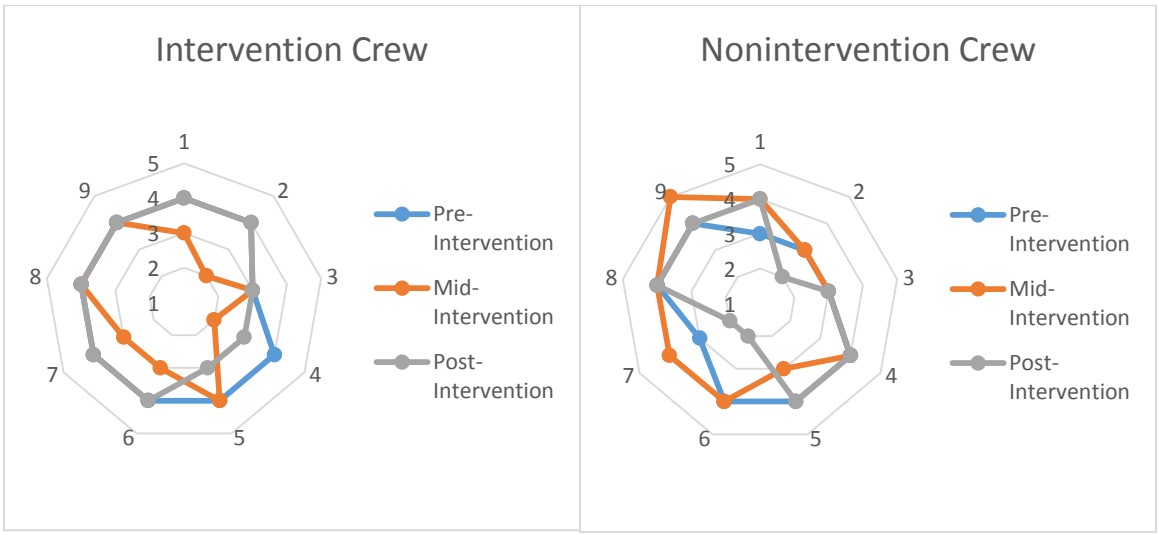


Figure 6.23 Hazards in my section are corrected in an appropriate amount of time.

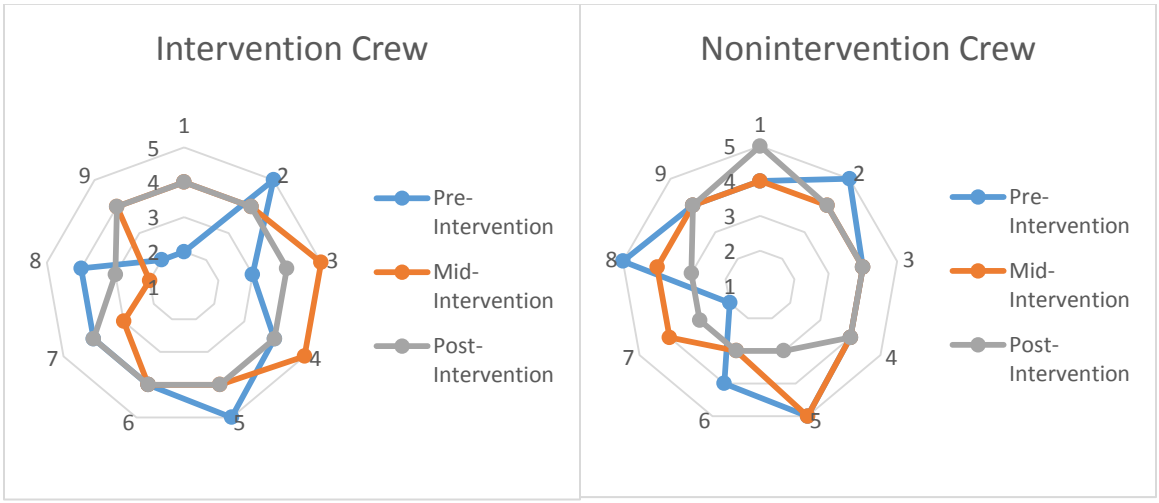


Figure 6.24 Miners in My Crew Work Just as Safely When the Direct Supervisor is Not Around.

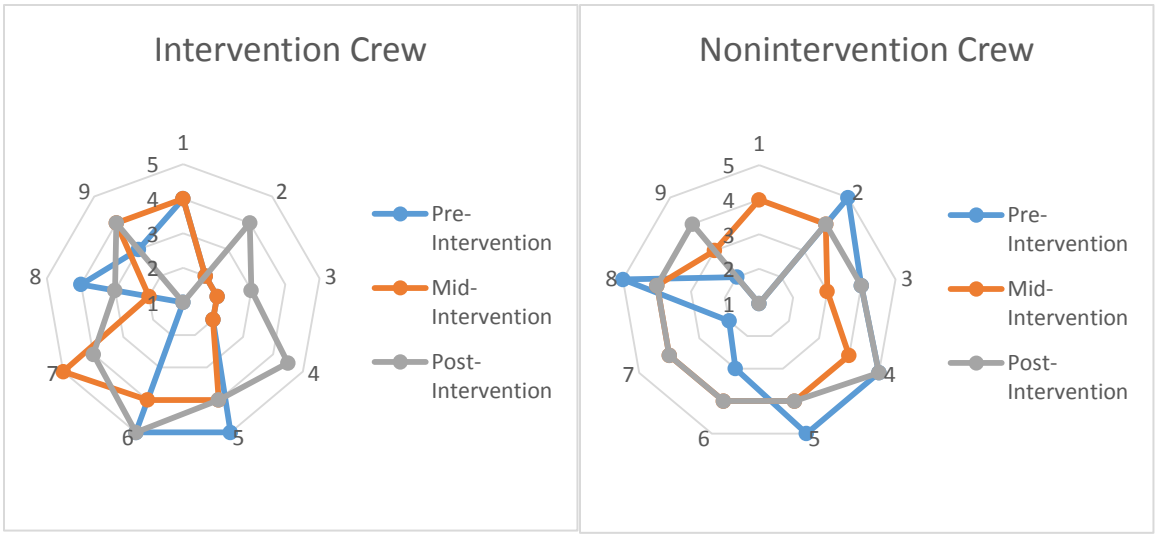


Figure 6.25 Miners are Responsible for Their Own Safety in My Section.

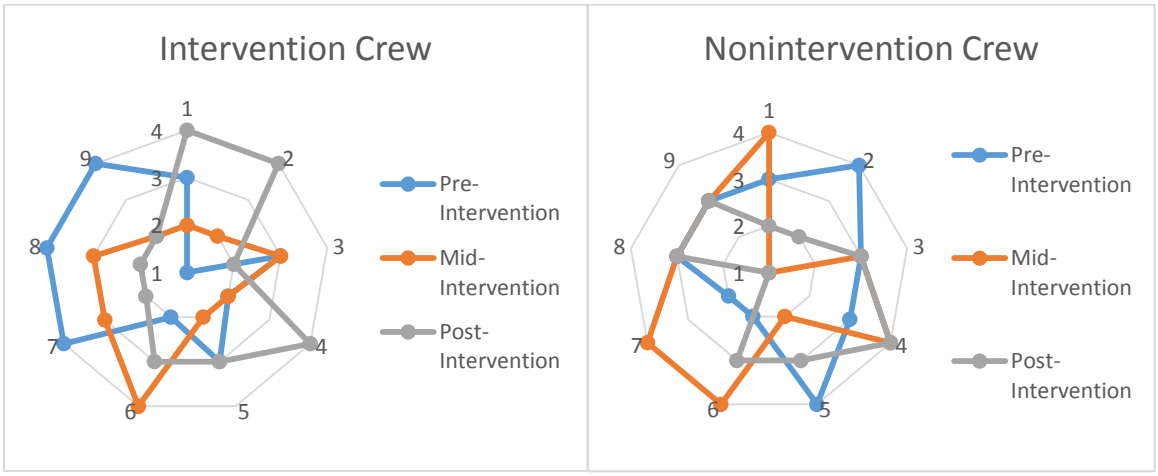


Figure 6.26 The Equipment in My Section is Properly Maintained.

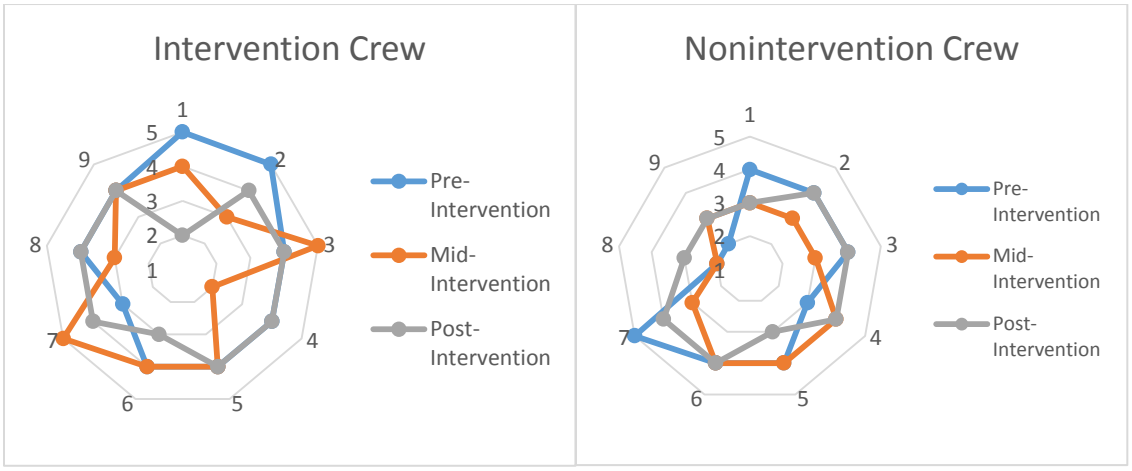


Figure 6.27 Workers at This Mine Sometimes Take Unnecessary Risk to Get the Job Done.

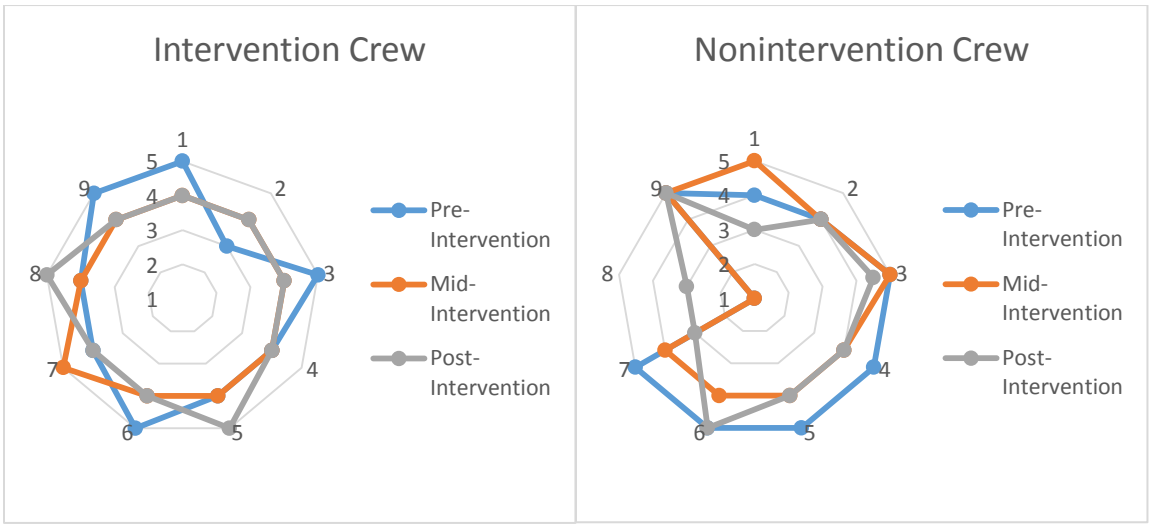


Figure 6.28 My Decisions Effect the Safety of Other Miners in My Crew.

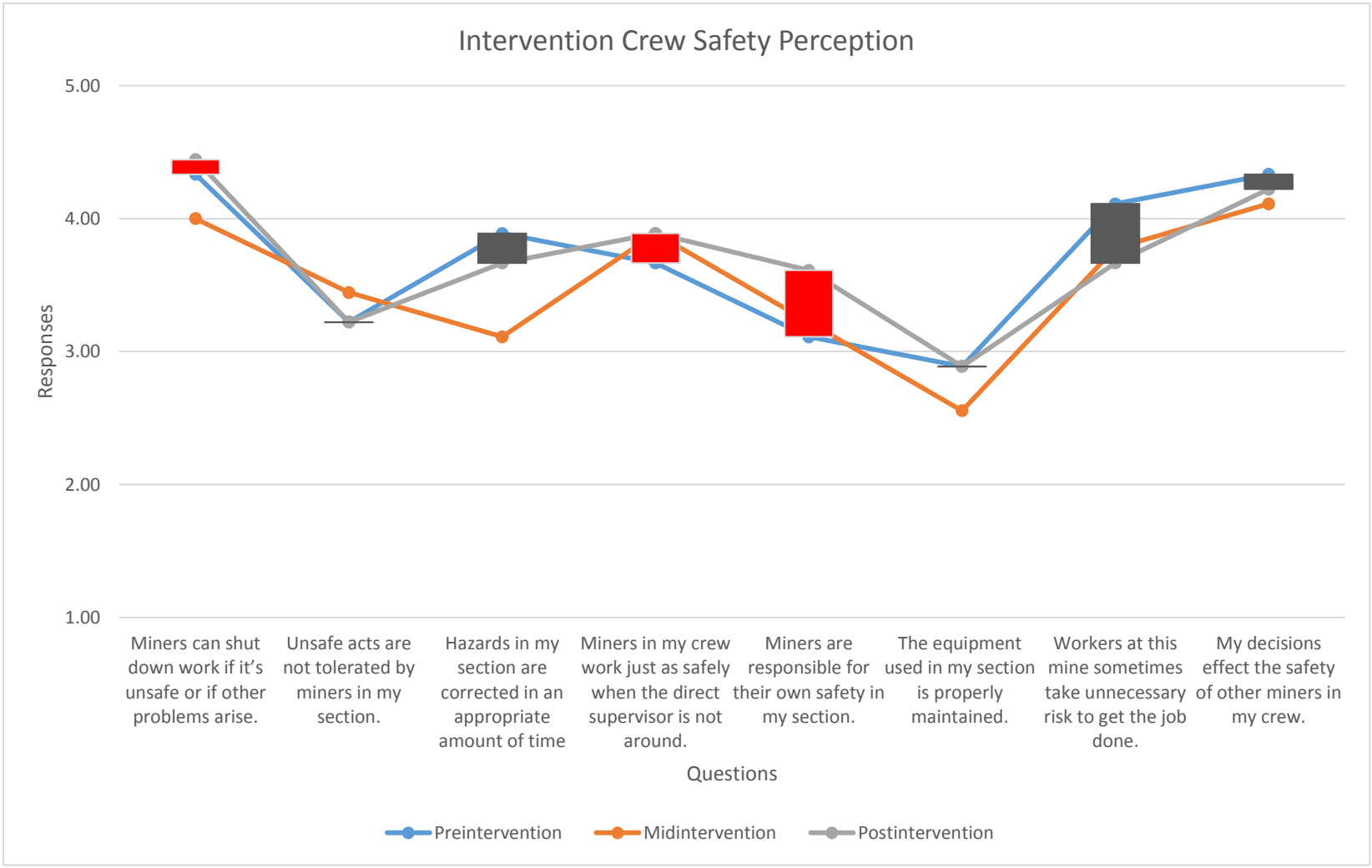


Figure 6.29 Intervention Crew Safety Perception

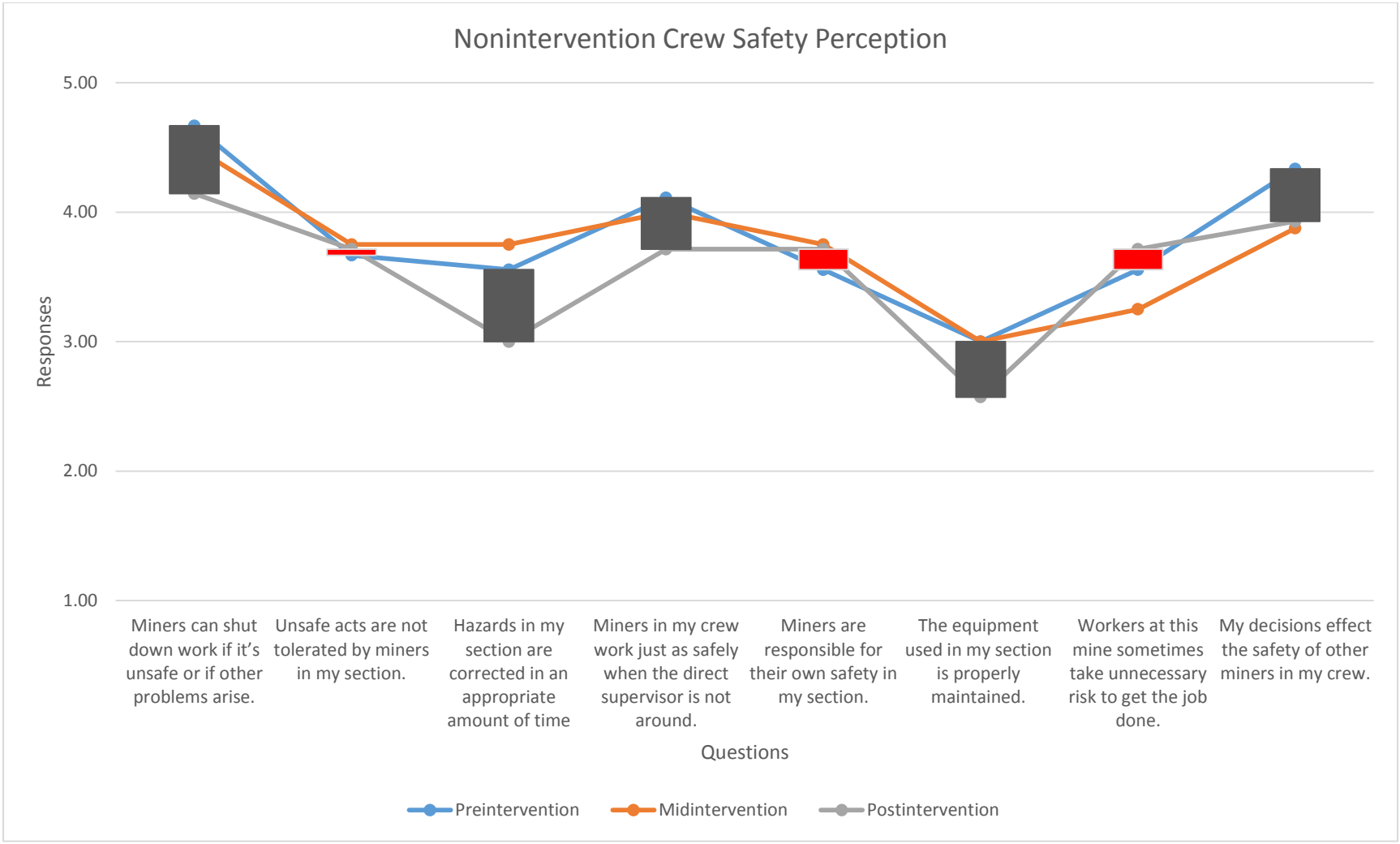


Figure 6.30 Nonintervention Crew Safety Perception

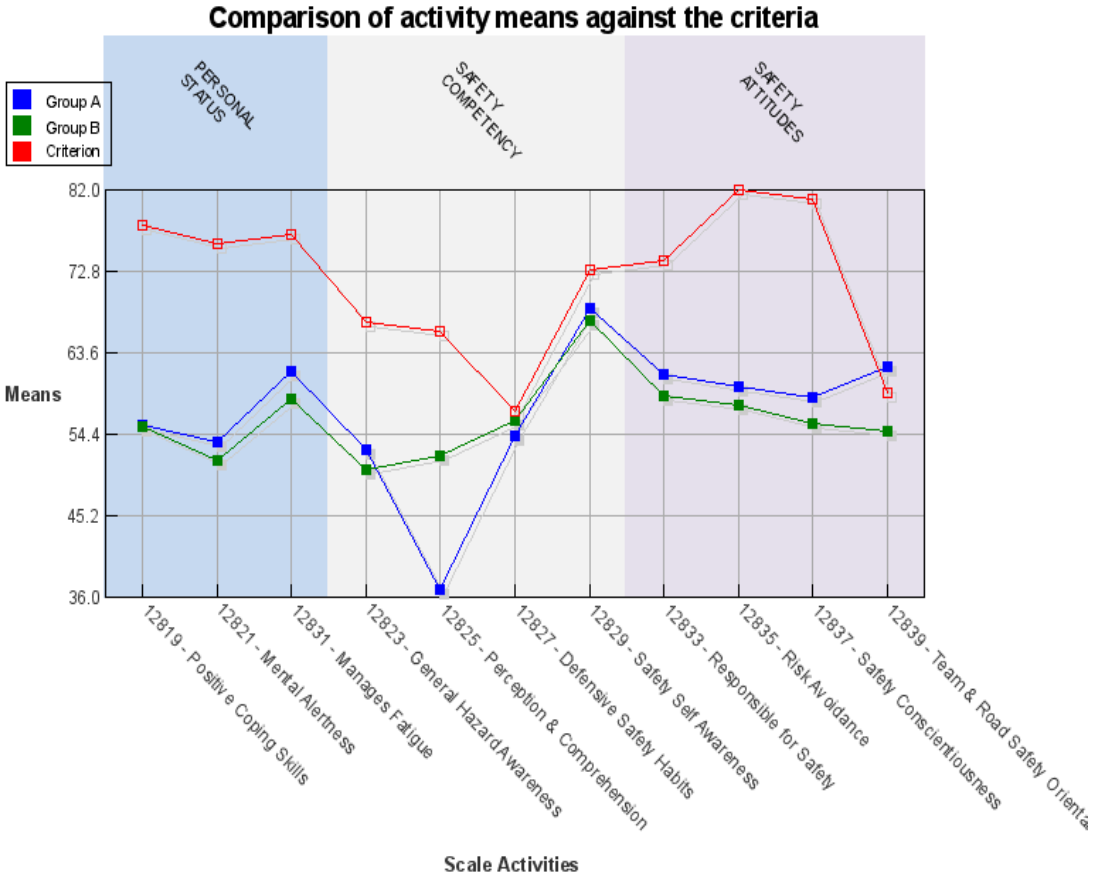


Figure 6.31 Situational Safety Awareness for the Intervention Crew.

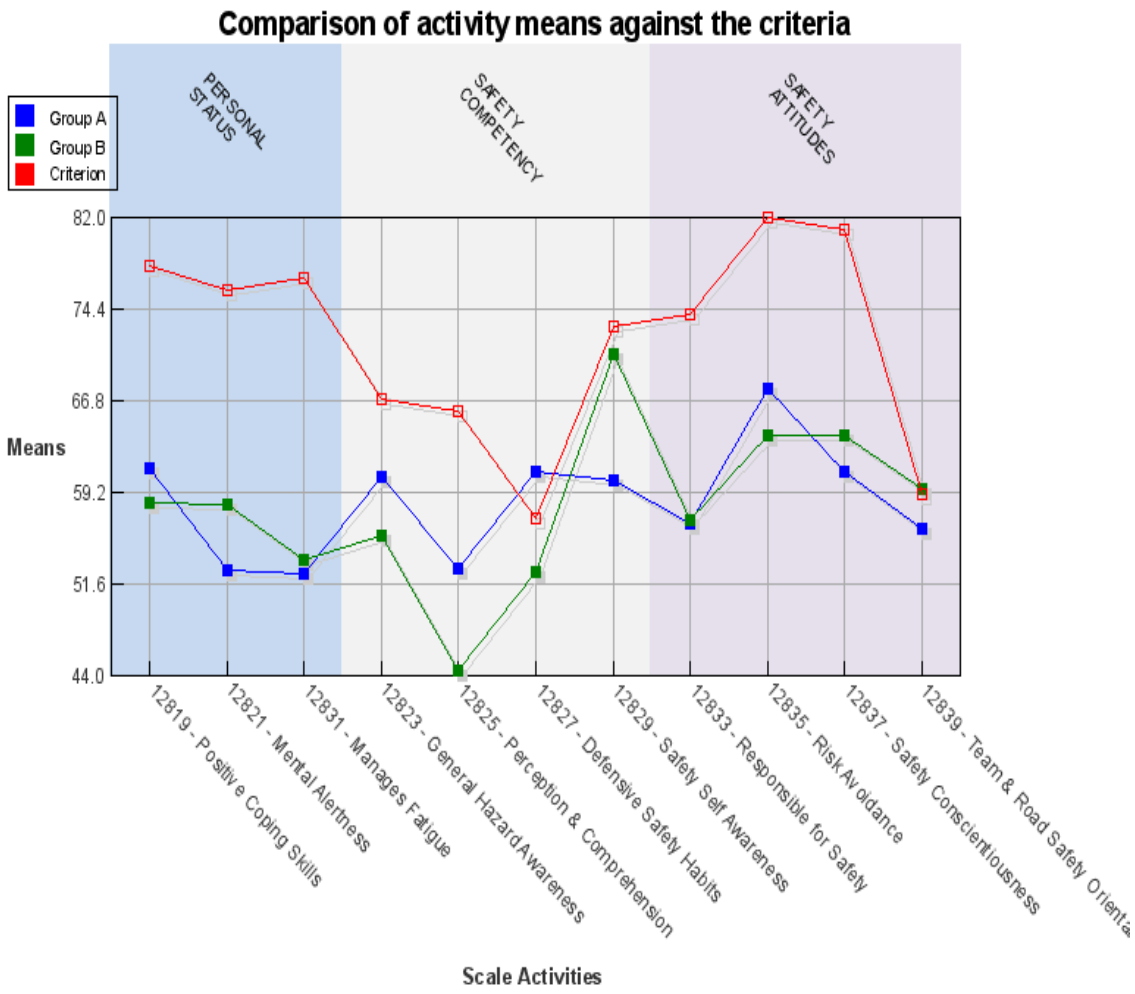


Figure 6.32 Situational Safety Awareness for the Nonintervention Crew.

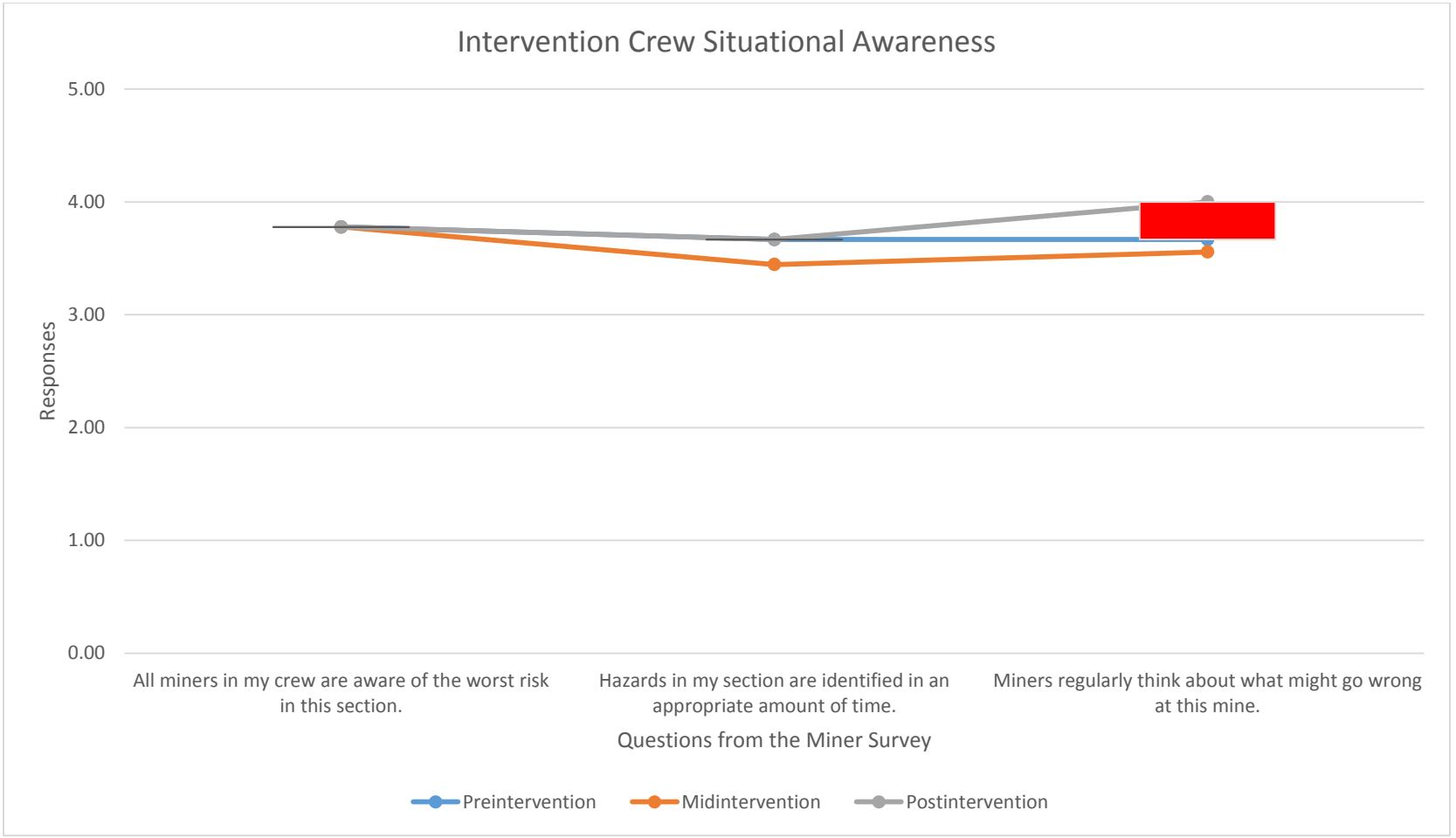


Figure 6.33 Situational Awareness for the Intervention Crew

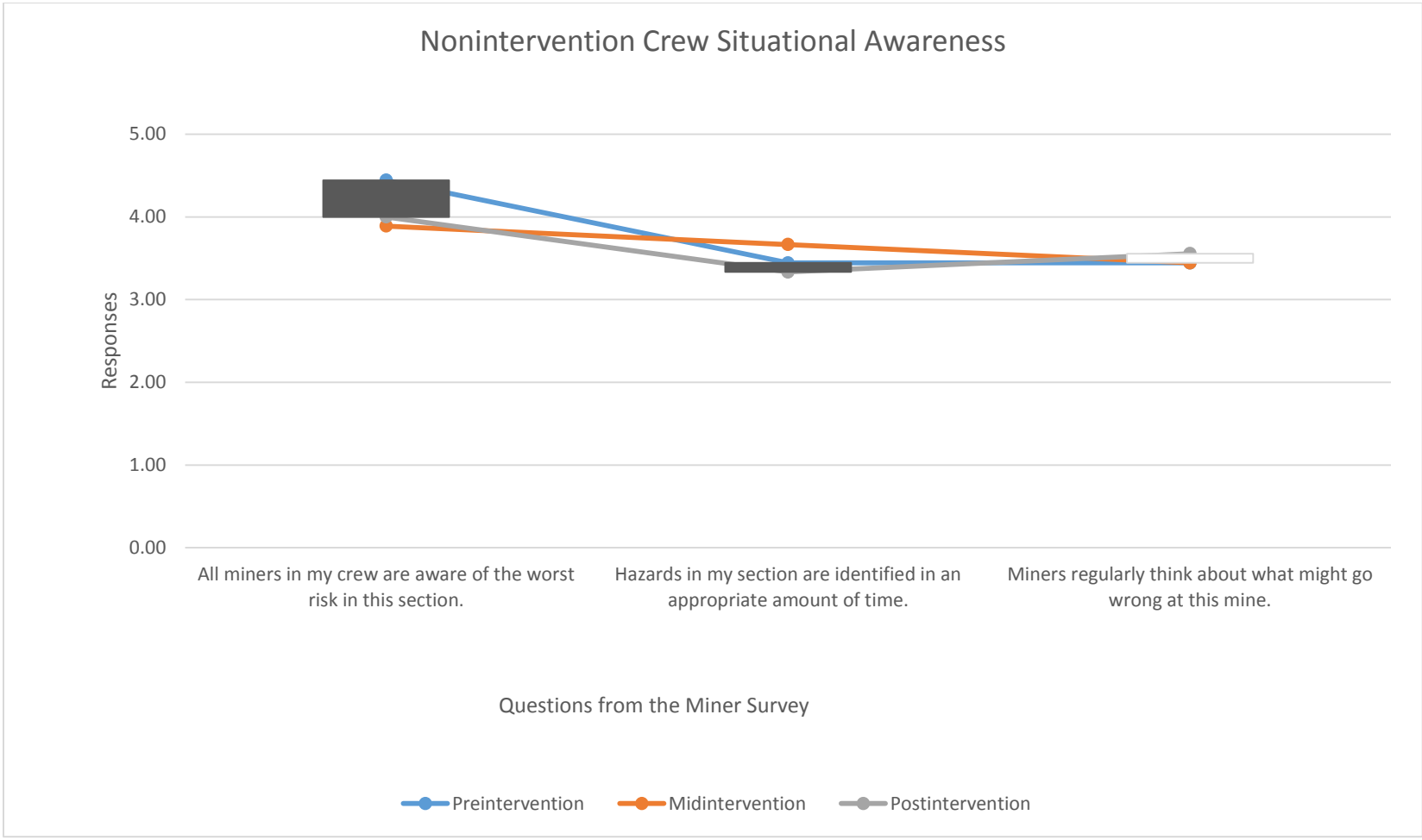


Figure 6.34 Situational Awareness for the Nonintervention Crew

7. CONCLUSION

7.1 Hypothesis$_0$

H_o: An increase in leadership climate through training and implementation of a variant of distributive leadership correlates to a positive change in psychological empowerment among individual miners in an underground coal mining section.

Survey responses regarding perception of leadership qualities that define shared leadership, i.e., a dynamic interactive influence process among individuals in groups, for which the objective is to lead one another to the achievement of group or organizational goals or both (Pearce and Conger 2003), indicated that overall, miners received fewer opportunities to participate in the crew's decision making process, which nullifies hypothesis$_0$; see Figure 6.1.

Positive and negative changes in shared leadership can be argued. The pre-intervention survey responses represented a consensus of empowerment among miners to make decisions (see Figure 6.1), and a positive perception of accountability and responsibility (see Figure 6.15). A majority of the miners could not explain the difference between accountability and responsibility before receiving leadership training. Before the intervention, miners developed a sense of confidence in performing individual routine tasks, and making decisions regarding those tasks. When charged with making decisions outside those routine tasks, i.e., decisions that affected outcomes for the whole section, the perception of shared leadership decreased. It is likely that this was due to an

increased awareness of the foreman's responsibilities and control over the section prior to the intervention. Overall the increase in awareness of responsibilities between the miners, fire boss, and foreman, resembled a positive change in leadership climate. This awareness of responsibilities outside of individual routine tasks is a primary step in leadership development and indicator that some preliminary form of shared leadership was being enacted among the crewmembers.

A key learning point from this study is that leadership development requires varying amounts of time, effort, resources, and support from multiple levels in an organization. While shared leadership was implemented at the individual and frontline supervisor levels, upper management and shift supervisors were practicing routine methods of management that were counterproductive to shared leadership. Further research will help to define the organizational level within a mining operation where the traditional hierarchical methods of leadership should meet methods of shared or distributive leadership, and determine the most effective traditional hierarchical leadership models or competencies that support the implementation and development of shared leadership.

In addition to the evidence that some preliminary form of shared leadership was occurring in the section, interviews, observations, and the intervention diary, indicate an overall increase in leadership climate, contrary to decrease calculated in the statistical analysis of the perception surveys. The significant decrease in perception of traits used to define the leadership climate construct, i.e., trust, communication, task proficiency, dependability, and accountability, represent an initial step in the process of leadership development, which indicates an increase in leadership climate. The study design

included metrics to observe significant changes in leadership climate as a whole, but did not include metrics to identify the preliminary and incremental stages of development that occurred during the intervention. The possibility of a type II error is relevant in a replication of this study with more participants, though a legitimate time-series design over six-months to a year will account for significant changes.

Certain increases and decreases in psychological empowerment may also support the argument of an increase in leadership climate. Again, responses taken through mid-intervention and postintervention surveys (after the leadership training), indicate a decrease in perception of job impact and increase in perception of job meaningfulness. The shift in Likert scale responses to the statement, "I have considerable opportunity for freedom and independence in how I do my job," and "my impact on what happens in my section is large," was approximately minus one or 16% (see Figure 6.17). This is a significant change in perception considering the sample size, and could support the argument of an increased awareness of job responsibilities and accountability among the miners, fire boss, and foreman. Whereby this also supports nullification of hypothesis$_0$, it is evident that the intervention was not effectively implemented. Responses taken from the nonintervention crew remained mostly uniform through the pre-, mid-, and post-intervention surveys. This proved to be useful for comparing and analyzing the changes in responses of the intervention crew.

A replication of this intervention with the duration lasting six months to a year, and with additional time series measures, is likely to render more conclusive results. Also, additional logistical support (i.e., financing for travel and time, and additional personnel) would provide a means for a more thorough implementation of the leadership

structure. Confounding factors beyond control of the intervention administrators would still remain an issue, such as the negative political outlook on the future of coal in the United States, and increased demand for production amidst other prohibiting factors such as worn down equipment, cuts in incentives, and environmental hazards.

7.2 Hypothesis$_1$

H_1: An increase in psychological empowerment correlates positively to a change in productivity, perception towards safety and situational awareness among individual miners in an underground coal mining section.

Considering the nullification of Hypothesis$_0$, no correlation can be determined for psychological empowerment as a whole with productivity, safety, or situational awareness. Productivity decreased, but this was due to the year-end schedule, holidays, and employees using vacation. The intervention and nonintervention crews performed at different and varying levels of hourly production, but the duration of the intervention was not long enough to record a sufficient amount of data to determine any conclusive trends. A major recommendation for the replication of this study would be to incorporate a longer time-series design, more than one year if possible.

Responses to questions regarding perception of safety did indicate some positive changes in perception among the intervention crew. Mainly, there was an increase of individual responsibility for safety and a decrease in overall willingness of miners to take risk to get the job done; see Figure 6.31. The nonintervention crew also indicated a positive change in perception of individual responsibility for safety, though less than the intervention crew, by .3 on the Likert scale. Also, where the intervention crew indicated a decrease in willingness of miners to take risk in getting the job done, the nonintervention

crew reported an increase. This is significant considering the increased demand for production for both crews in the section.

Responses to questions from the miner survey regarding situational awareness showed only slight changes in perception; see Figures 6.35 and 6.36. The questions were intended to supplement data collected through the situational safety awareness survey provided by Psyfactors, Ltd., which also indicated only slight changes in perception of situational awareness. If this survey was completed by the miners within the confounds of the intent it was designed for (i.e., to determine the cognitive abilities of a potential employee), a stronger effort may have been given, and thus, more reliable data produced.

7.3 Summary

Considering the complexity of challenges in the mining industry and improved standards for acceptable risk, innovation must exceed the means of technology and typical linear engineering solutions. The stability of mining operations no longer depends on the willingness of workers to sacrifice in extremely hazardous conditions. The modern workforce must be empowered, situationally aware, decisive, and able communicators. Though this intervention was conducted at a small level and the quantifiable outcomes were not significant, this research unravels a multitude of possibilities for both innovation and safety through leadership development.

The qualitative data collected during the interviews and observations provided evidence of the importance and transitional nature of psychological empowerment. This is significant, when considering a higher standard for safety in the mining industry. While any mine operator would hopefully vouch for the ability of their employees to “stop unsafe work,” traditional methods of management and leadership are counterproductive

to empowering employees with any voice regarding the nature of their work, that being overall safe practices and identification of potential hazards, or process improvements.

A replication of this study would benefit from an increased duration of the intervention, while maintaining a time series design, additional research administrators to effectively implement the intervention, and a larger, more randomly selected cohort. The cohort in this study was behind budget on production and was selected by mine management based on their need for improvement. This combination of confounding factors made the intervention very difficult to implement. Also, utilization of a larger cohort that is not under the same pressure to increase production and selected with the intent to improve perceived poor attitudes, will prove more useful for validating data and other outcomes against other inevitable confounding factors.

Future research in the mining industry would be beneficial from more in-depth investigations of the relationship between leadership and situational awareness. In the military, leadership serves as a platform that enables a learning culture-which is capable of adapting, to efficiently manage crisis. This ability to adapt requires a decentralization of authority and has been described as imperative for U.S. Joint Special Operations Task Forces in Afghanistan and Iraq (McChrystal et al. 2015). In crisis, adaptive organizational responses require the ability to quickly transform organizational structures and decentralize, rather than relying on hierarchy and centralized autonomy (Grabowski and Roberts 2016).

The question is, do high-risk environments and crisis-situations compare? Can the same leadership applications used to establish a learning culture in high reliability organizations prove to be effective in other high-risk industries? This application of

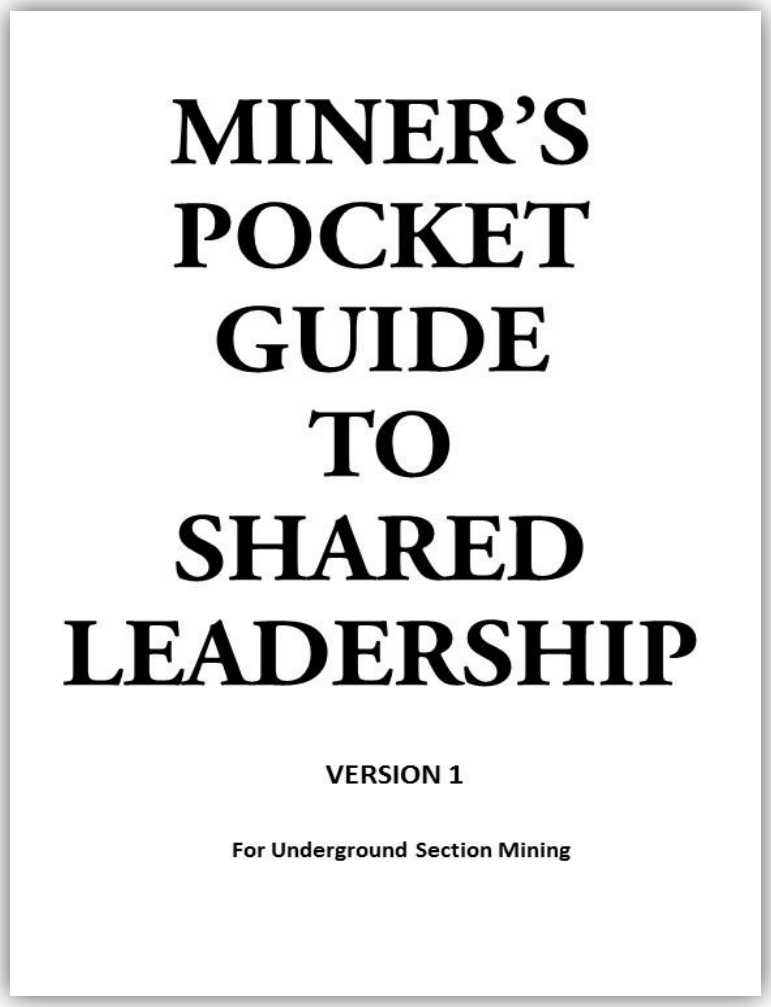
leadership is one of many that may be effective. In addition to improvements in study design, alternate approaches to the study's implementation could be useful, such as focusing more on the small unit, providing training based on the same traits and principles to front-line managers, and team leaders through-out an entire mine.

7.4 List of Observations from the Study

1. The qualitative data collected during the interviews and observations provided evidence of the importance and transitional nature of psychological empowerment.
2. A majority of the miners could not explain the difference between accountability and responsibility before receiving leadership training.
3. There was an increase of individual responsibility for safety and a decrease in overall willingness of miners to take risk to get the job done.
4. There was an increased awareness of job responsibilities and accountability among the miners, fire boss, and foreman.
5. Targeting the small unit level rather than individuals may be more effective for implementing leadership development in future.

APPENDIX A

MINERS POCKET GUIDE TO SHARED LEADERSHIP



Contents

Mindset

A set of beliefs or way of thinking that determines one's behavior, outlook and attitude

Growth Mindset

- I enjoy learning
- I listen when people are talking
- I learn something new when I fail
- Im open to new suggestions
- I try to get better at what I do
- Improving things keeps me interested
- I am interested in ways to make my life better

Fixed Mindset

- I already know
- I know what people are going to say
- I don't fail very often
- I know what works best
- I'm already good at what I do
- I already know what Im supposed to do
- My life is just what it is

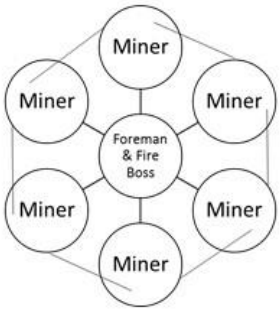
Reference: Collaborative Consulting

DON'T BE AN AIR THIEF!

3

What is Shared Leadership?

- A process whereby an individual influences a group of individuals to achieve a common goal.
- When we define leadership as a process, it means that it is not strictly a set of traits or characteristics upheld by one individual (the leader), but a transactional event that occurs between a leader and followers.
- With this understanding, leadership is not a linear event restricted to the formally designated leader of the group, but an interactive event where leadership is available to everyone.
- Leadership involves influence. It is concerned with how the leader affects followers, without influence leadership does not exist.



4

Leading or Managing

They are two different skills, but often confused.

Leadership	Management

• Influence
• Change and movement
• The skill of **Leading** has been around for ages and has generally been concerned with influencing people to accomplish great things under not great circumstances.
• Skills
  • Establish Direction
  • Aligning People
  • Motivating and Inspiring
• Seeking adaptive and constructive change
	• Control
	• Order and consistency
	• The skill of **Managing** was created during the industrial revolution to prevent chaos in the work place as small workshops turned into giant factories.
	• Skills
	  • Planning
	  • Organizing
	  • Staffing
	  • Controlling
	• Seeking order and stability

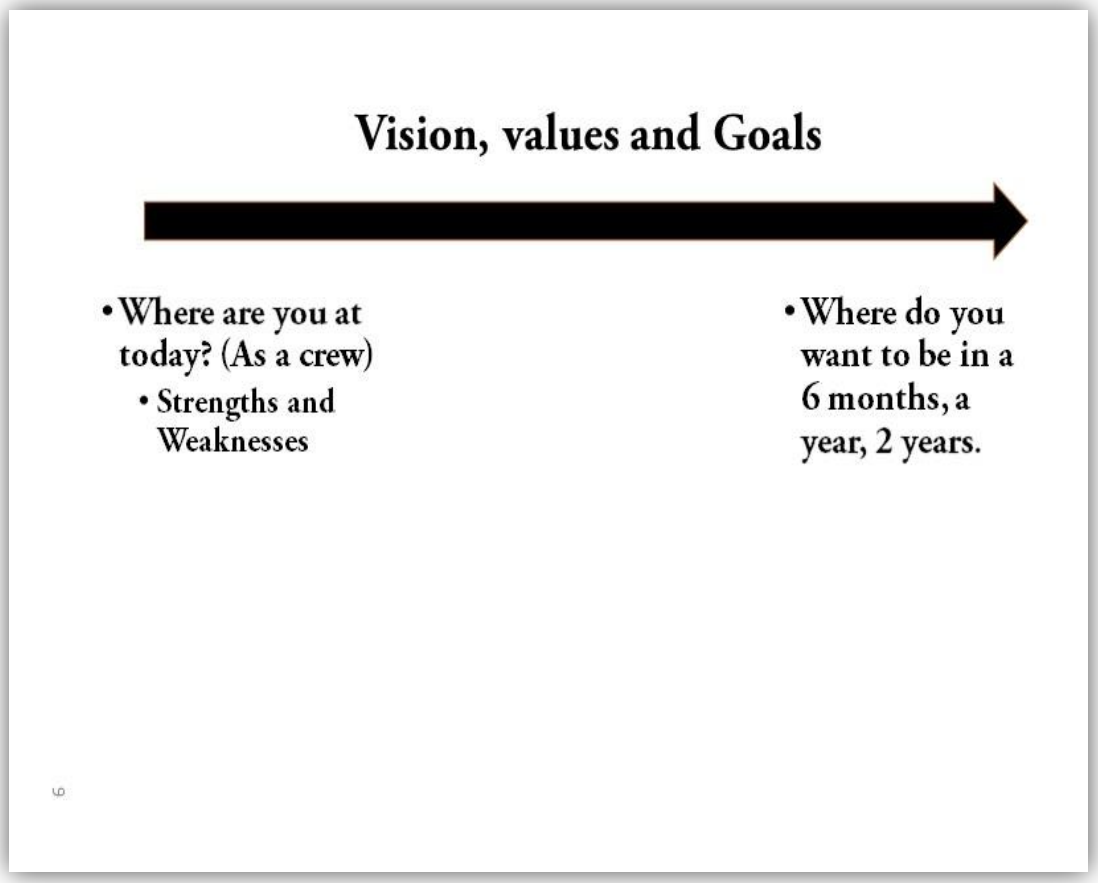
Reference Leadership by Peter G. Northouse

5

Leadership Structure Comparison

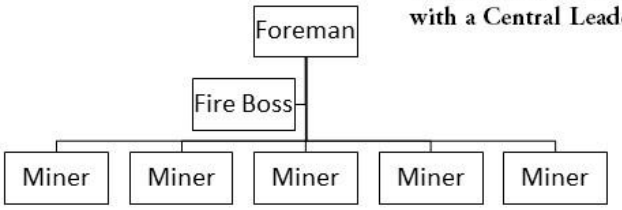
Traditional Leadership	Shared Leadership
• One person assumes a leadership role, in the hierarchy of leadership • Tasks (detailed) are directed from the central leader • Responsibility and accountability lies on foreman • Miners are seen as subordinates, proper work flow requires miners to follow direct instructions • Communication is benefit, but not as important as following directions	• All members of a crew assume leadership roles • Task are coordinated by the foreman and fire boss, details of the task are decided by the miner. • Responsibility and accountability are held by each miner • Task priority, process and delegation is handled by miners • Communication is vital among all members of the section • Trust is vital among all crew members • Vision, Values and Goals are important to align all crew members

6

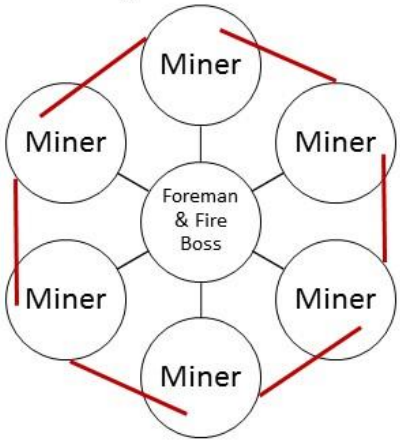

Vision, values and Goals
• Where are you at today? (As a crew)
• Strengths and Weaknesses
• Where do you want to be in a 6 months, a year, 2 years.
9

Leadership Structure Comparison

Traditional Structure with a Central Leader



Shared Leadership



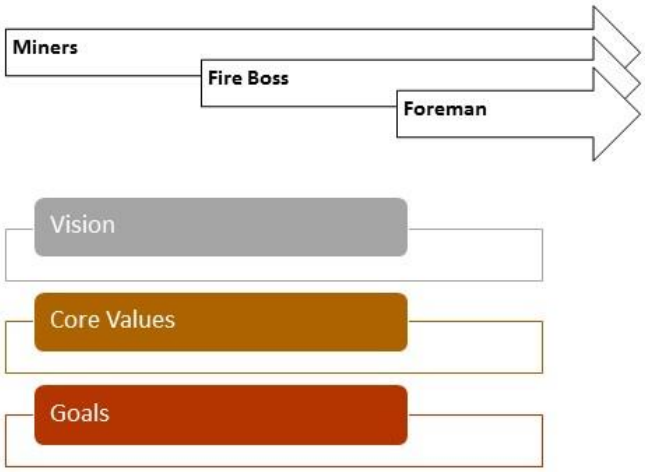
7

General Leadership Styles

There are multiple approaches to being an effective leader. Different situations call for different strategies in moving people towards a common goal, set of values or vision.

Transformational Leadership

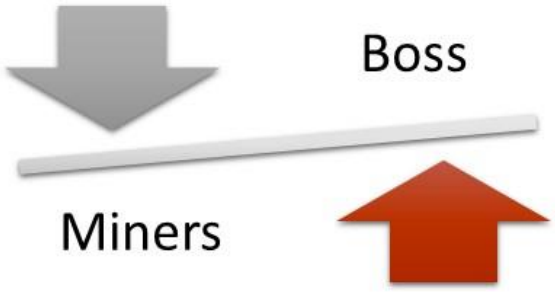
Uniting people towards a common cause or goal through a vision. This kind of leadership requires a leader to heavily interact with followers or peers to understand their individual strengths and weaknesses and properly coordinate these abilities so that the team stays on the visions path and goals are achieved.

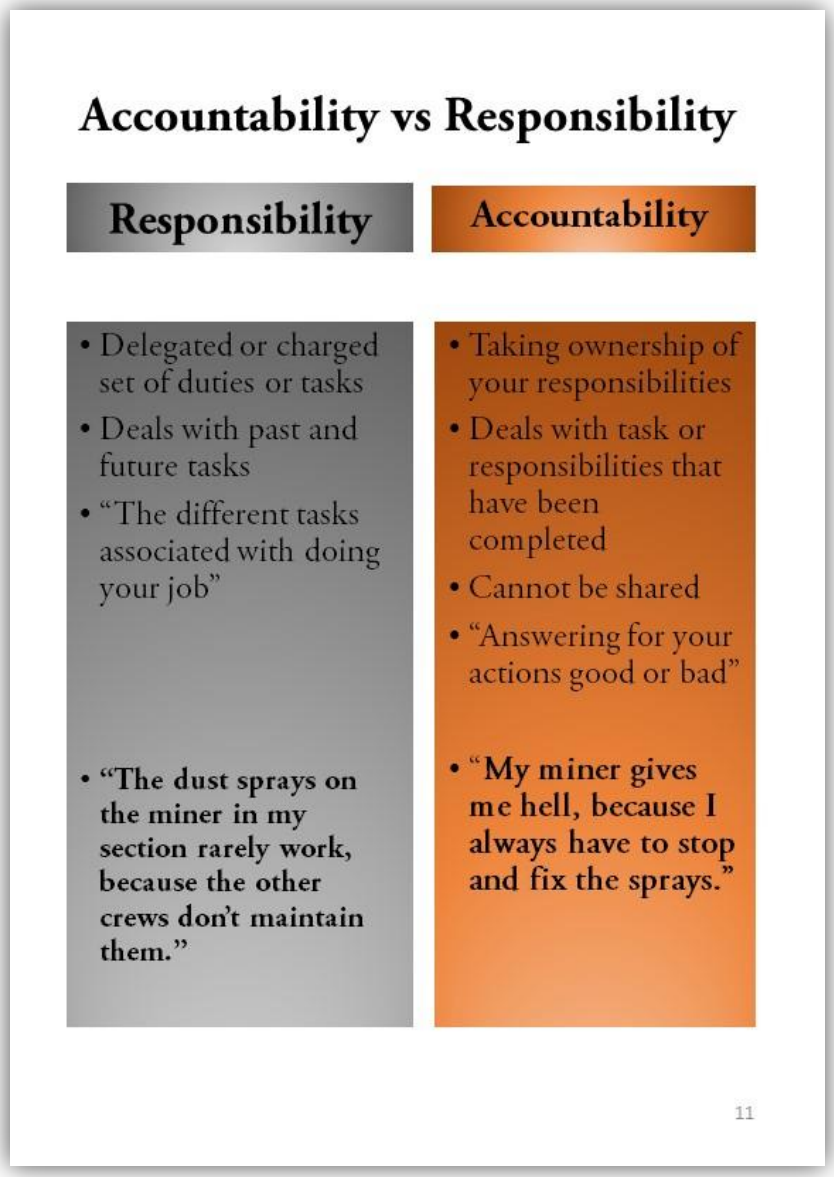


8

Transactional Leadership

- Driving followers (subordinates) to a goal through a contract, (for example: a boss pays an employee a certain amount to finish a job within a certain time). This approach involves less interaction among followers, but can involve stricter and more involved oversight.




Accountability vs Responsibility
Responsibility
Accountability
• Delegated or charged set of duties or tasks
• Deals with past and future tasks
• "The different tasks associated with doing your job"
• "The dust sprays on the miner in my section rarely work, because the other crews don't maintain them."
• Taking ownership of your responsibilities
• Deals with task or responsibilities that have been completed
• Cannot be shared
• "Answering for your actions good or bad"
• "My miner gives me hell, because I always have to stop and fix the sprays."
11

Leadership Principles and Traits

- In the past, strong political, religious and military leaders were thought to be born with certain leadership traits. Currently the most effective leaders don't rely on these traits alone, but they are a good foundation for developing leadership.

- **Principles**
  - Know yourself and seek self-improvement
  - Know your fellow miners and look out for their welfare
  - Seek responsibilities and take ownership of your responsibilities (accountability)
- **Traits**
  - **Judgment**- the ability to weigh facts and possible courses of action in order to make sound decisions
  - **Dependability**- the certainty of proper performance and duty
  - **Decisiveness**- the ability to make decisions promptly and to announce them in a clear manner
  - **Knowledge**- the range of one's information, including professional knowledge and and understanding of co-workers
  - **Trust**- reliance on the integrity, strength, ability of another person
  - **Integrity**- adherence to moral and ethical principles

12

Communication

- **Drills**- Lead a training exersize responding to a simulated fire or other emergency. For example (dressing a wound, rescue breathing, responding to an electrical hazard, doning SCSR, ect..). Hold a debrief so that all miners can give and receive feedback

- **CROSS TRAINING**- Give a quick class on either a piece of equipment or task that you are particularly good/experienced at to sharpen fellow miners skills. Chat with a mechanic or electrician to learn more about the capabilities of equipment in your section. Don't assume everyone knows what you know.

- **360 Feedback** – Discuss the strengths and areas that need to be improved for all miners regarding work tasks, leadership abilities, communication ect…

- **Feedback**- You don't need a special meeting if you see it then and there, if it looks like someone is doing it better way than normal point it out, if it could be done better point it out. Atta boys don't have to come from a boss. A written and verbal form of this is useful.

13

RATE YOURSELF- Determine where you stand with the previous traits and principles. Efficient means that you already do it and could teach it to other miners. Insufficient means it's an area you need to improve.

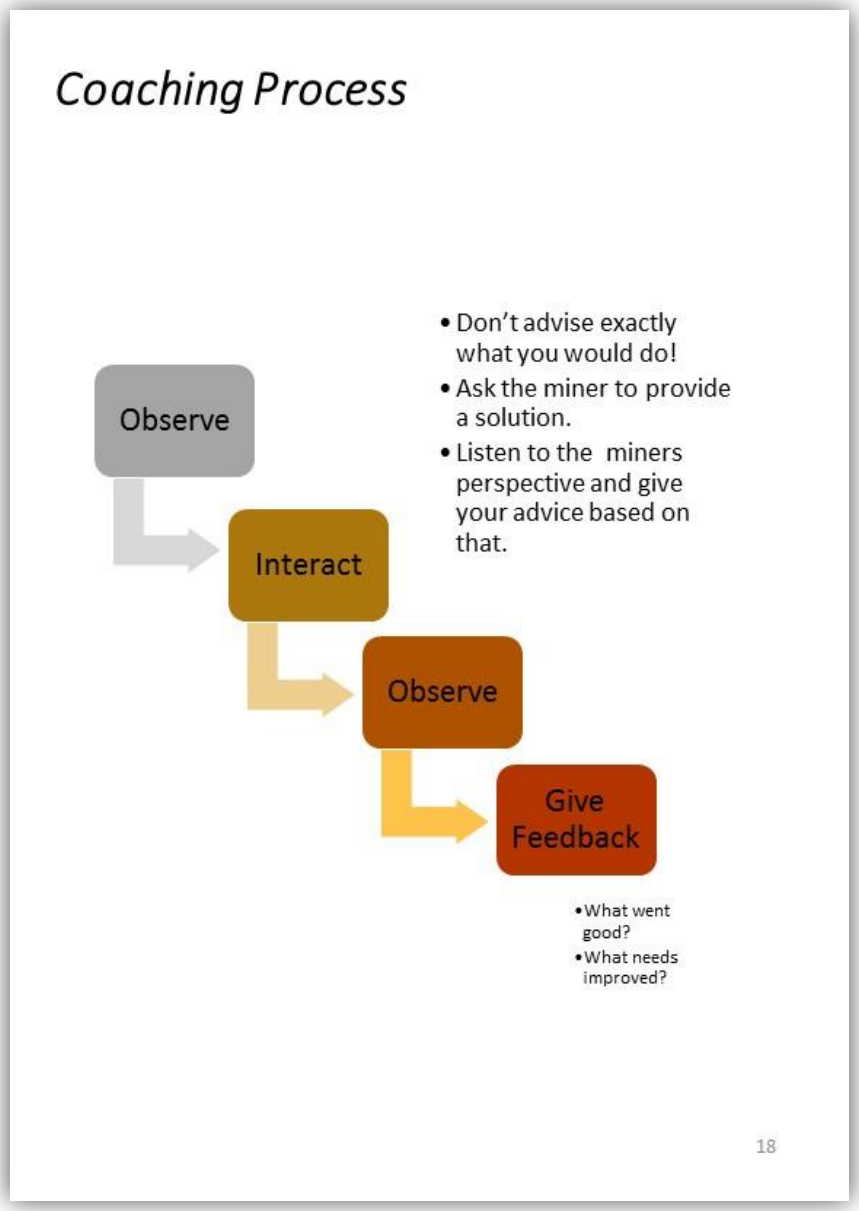
- **EFFICIENT**
  Traits/ Principles

- **INEFFICIENT**
  Traits/Principles

Action Plan

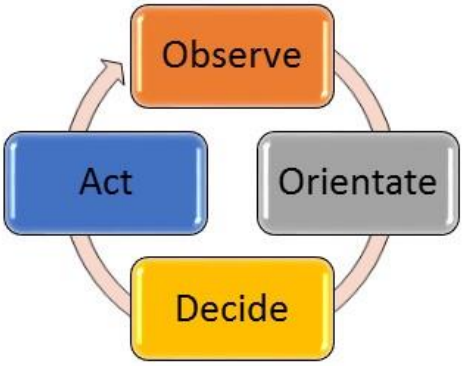
- What are you efficient at?
- What are you inefficient at?
- What **assets** are available to help you improve your insufficient leadership traits/principles ?
- What assets are not available- how can you acquire them?
- What tools can you use to better communicate with fellow miners?
- How often do you provide feedback to fellow miners for their performance?
- In what timeline do you hope to improve your skills?

16


Coaching Process
Observe
Interact
Observe
Give Feedback
• Don't advise exactly what you would do!
• Ask the miner to provide a solution.
• Listen to the miners perspective and give your advice based on that.
• What went good?
• What needs improved?
18

Decision Making

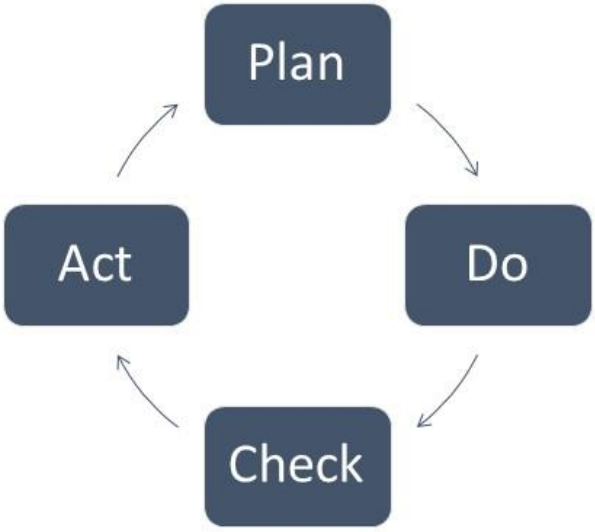
OODA LOOP



- **Observe**
  - What's the problem?
  - Who's involved?
  - What are the conditions?
  - What time is it?
- **Orientate**
  - What do you need to accomplish?
  - In what time does it need to be done?
  - Who do you need to do it?
- **Decide**-Decide what to do
- **Act**- Do it.

Process Improvement

Deming Cycle of Process Improvement



- **Plan**- Create a plan or write-out the existing plan.
- **Do**- Put the plan into action.
- **Check**- See what works well about the plan and what needs improved.
- **Act**- Take on action on required improvements.
- **Plan**- Modify the plan to include new improvements.

Task Inventory

Miner Operator	Bolters	Car Drivers	Pre-Shifts

21

Risk Analysis

Task	Risk Involved	Consequences if Risk Occurs	Controls to Put in Place
Operating Shuttle Car	Struck By People Ribs Ventilation Cables Smashing other cables	Serious Injury or Death Creating jagged mesh and unsafe rib conditions, excessive damage to cars Shut down mining to make repairs	Walk pathways before operating Communicate with miners around you before turning on equipment or operating equipment Ensure your pathway is clear

22

APPENDIX B

MINER PERCEPTION SURVEY VERSION 1.4

UNIVERSITY OF UTAH MINER PERCEPTION SURVEY VERSION 1.4

This survey is being conducted to asses perceptions of your mine's leadership culture and situational awareness. Please answer each question based on how you currently feel and not how you felt in the past, or how someone else might expect you to answer. **This survey is confidential-do not include your name.**

		Strongly Agree	Agree	Neutral	Disagree	Strongly Disagree
1	Miners can shut down work if it's unsafe or if other problems arise.	☐	☐	☐	☐	☐
2	All miners in my crew are aware of the worst risk in this section.	☐	☐	☐	☐	☐
3	Unsafe acts are not tolerated by miners in my section.	☐	☐	☐	☐	☐
4	I trust my direct supervisor.	☐	☐	☐	☐	☐
5	Miners in my crew make decisions regarding what needs to get done.	☐	☐	☐	☐	☐
6	Hazards in my section are identified in an appropriate amount of time.	☐	☐	☐	☐	☐
7	Hazards in my section are corrected in an appropriate amount of time	☐	☐	☐	☐	☐
8	Miners in my crew work just as safely when the direct supervisor is not around.	☐	☐	☐	☐	☐
9	My direct supervisor and I communicate well.	☐	☐	☐	☐	☐
10	Miners are responsible for their own safety in my section.	☐	☐	☐	☐	☐
11	The equipment used in my section is properly maintained.	☐	☐	☐	☐	☐
12	Miners work alone with supervision for the majority of their work shift.	☐	☐	☐	☐	☐
13	Miners understand what their supervisor expects of them in this section.	☐	☐	☐	☐	☐
14	Miners in my section are encouraged to find better wats to do things.	☐	☐	☐	☐	☐
15	Miners in my section make decisions regarding how things should get done.	☐	☐	☐	☐	☐
16	I influence the other miners in my section.	☐	☐	☐	☐	☐
17	Team work is valued to get things done in my section.	☐	☐	☐	☐	☐
18	Miners regularly think about what might go wrong at this mine.	☐	☐	☐	☐	☐
19	Decisions that I make benefit my crew.	☐	☐	☐	☐	☐
20	My crew members can depend on me.	☐	☐	☐	☐	☐
21	Miners in my section make decisions regarding when things should get done.	☐	☐	☐	☐	☐
22	Miners in my crew are comfortable making decisions	☐	☐	☐	☐	☐
23	Workers at this mine sometimes take unnecessary risk to get the job done.	☐	☐	☐	☐	☐
24	I am familiar with the strengths and weakness of my crew members.	☐	☐	☐	☐	☐
25	Miners receive regular feedback and coaching from supervisor.	☐	☐	☐	☐	☐
26	The feedback and coaching received from my supervisor is effective.	☐	☐	☐	☐	☐
27	Concerns and suggestions are communicated to management when appropriate.	☐	☐	☐	☐	☐
28	Miners in my crew are knowledgeable about their job.	☐	☐	☐	☐	☐
29	I am held accountable for my responsibilities.	☐	☐	☐	☐	☐
30	My decisions effect the safety of other miners in my crew.	☐	☐	☐	☐	☐
31	Miners in my section are proficient at their job.	☐	☐	☐	☐	☐
32	Miners effectively communicate with each other in my section.	☐	☐	☐	☐	☐
33	My direct supervisor keeps miners informed of activities and changes at this mine.	☐	☐	☐	☐	☐
34	My direct supervisor makes all the decisions.	☐	☐	☐	☐	☐
35	I trust the miners in my crew.	☐	☐	☐	☐	☐
36	Everyone in my section is held accountable for their responsibilities.	☐	☐	☐	☐	☐
37	My direct supervisor is comfortable with change	☐	☐	☐	☐	☐
37	The work I do is very important to me	☐	☐	☐	☐	☐
38	My job activities are personally meaningful to me.	☐	☐	☐	☐	☐
39	The work I do is meaningful to me.	☐	☐	☐	☐	☐
40	I am confident about my ability to do my job.	☐	☐	☐	☐	☐
41	I am self-assured about my capabilities to perform my work activities.	☐	☐	☐	☐	☐

UNIVERSITY OF UTAH MINER PERCEPTION SURVEY VERSION 1.4

This survey is being conducted to asses perceptions of your mine's leadership culture and situational awareness. Please answer each question based on how you currently feel and not how you felt in the past, or how someone else might expect you to answer. **This survey is confidential-do not include your name.**

42	I have mastered the skills necessary for my job.	▭	▭	▭	▭	▭
43	I have significant autonomy in determining how I do my job.	▭	▭	▭	▭	▭
44	I can decide on my own how to go about doing my job.	▭	▭	▭	▭	▭
45	I have considerable opportunity for freedom and independence in how I do my job.	▭	▭	▭	▭	▭
46	My impact on what happens in my section is large.	▭	▭	▭	▭	▭
47	I have a great deal of control over what happens in my section.	▭	▭	▭	▭	▭
48	I have significant influence in what happens in my section.	▭	▭	▭	▭	▭
	I am a section foreman.	Yes ▭			No ▭	
	I am a section fire boss.	Yes ▭			No ▭	
	I am a section miner.	Yes ▭			No ▭	
	My years of experience at this mine.	0-1yrs ▫	1-2 yrs ▫	2-5 yrs ▫	5-10 yrs ▫	
	My total years of mining experience.	0-1yrs ▫	1-2 yrs ▫	2-5 yrs ▫	5-10 yrs ▫	

APPENDIX C

SITUATIONAL SAFETY AWARENESS SURVEY VERSION 5.0p

psyfactors

SSA Inventory

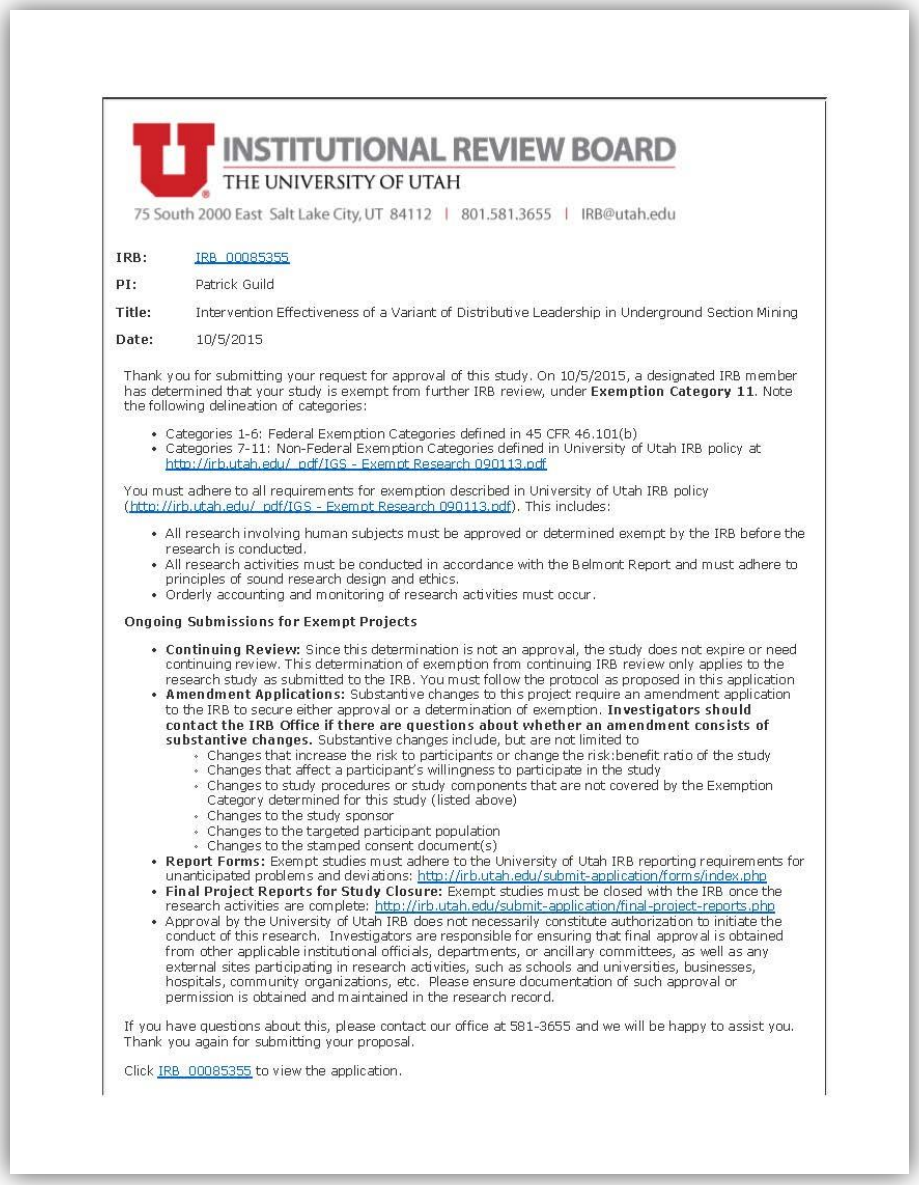
(*Mining*)

Questionnaire V5.0p

Patrick Guild University of Utah IRB

APPENDIX D

UNIVERSITY OF UTAH IRB CERTIFICATE



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THE UNIVERSITY OF UTAH

75 South 2000 East Salt Lake City, UT 84112 | 801.581.3655 | IRB@utah.edu

IRB: IRB_00085355

PI: Patrick Guild

Title: Intervention Effectiveness of a Variant of Distributive Leadership in Underground Section Mining

Date: 10/5/2015

Thank you for submitting your request for approval of this study. On 10/5/2015, a designated IRB member has determined that your study is exempt from further IRB review, under **Exemption Category 11**. Note the following delineation of categories:

- Categories 1-6: Federal Exemption Categories defined in 45 CFR 46.101(b)
- Categories 7-11: Non-Federal Exemption Categories defined in University of Utah IRB policy at http://irb.utah.edu/_pdf/IGS - Exempt Research 090113.pdf

You must adhere to all requirements for exemption described in University of Utah IRB policy (http://irb.utah.edu/_pdf/IGS - Exempt Research 090113.pdf). This includes:

- All research involving human subjects must be approved or determined exempt by the IRB before the research is conducted.
- All research activities must be conducted in accordance with the Belmont Report and must adhere to principles of sound research design and ethics.
- Orderly accounting and monitoring of research activities must occur.

Ongoing Submissions for Exempt Projects

- **Continuing Review:** Since this determination is not an approval, the study does not expire or need continuing review. This determination of exemption from continuing IRB review only applies to the research study as submitted to the IRB. You must follow the protocol as proposed in this application
- **Amendment Applications:** Substantive changes to this project require an amendment application to the IRB to secure either approval or a determination of exemption. **Investigators should contact the IRB Office if there are questions about whether an amendment consists of substantive changes.** Substantive changes include, but are not limited to
  - Changes that increase the risk to participants or change the risk:benefit ratio of the study
  - Changes that affect a participant's willingness to participate in the study
  - Changes to study procedures or study components that are not covered by the Exemption Category determined for this study (listed above)
  - Changes to the study sponsor
  - Changes to the targeted participant population
  - Changes to the stamped consent document(s)
- **Report Forms:** Exempt studies must adhere to the University of Utah IRB reporting requirements for unanticipated problems and deviations: http://irb.utah.edu/submit-application/forms/index.php
- **Final Project Reports for Study Closure:** Exempt studies must be closed with the IRB once the research activities are complete: http://irb.utah.edu/submit-application/final-project-reports.php
- Approval by the University of Utah IRB does not necessarily constitute authorization to initiate the conduct of this research. Investigators are responsible for ensuring that final approval is obtained from other applicable institutional officials, departments, or ancillary committees, as well as any external sites participating in research activities, such as schools and universities, businesses, hospitals, community organizations, etc. Please ensure documentation of such approval or permission is obtained and maintained in the research record.

If you have questions about this, please contact our office at 581-3655 and we will be happy to assist you. Thank you again for submitting your proposal.

Click IRB_00085355 to view the application.

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